US006631140B1

(12) **United States Patent**
Sjödin

(10) **Patent No.: US 6,631,140 B1**
(45) **Date of Patent: Oct. 7, 2003**

(54) **SHARED COMMUNICATIONS PROTOCOL LAYER FOR INTERFACING BETWEEN WIRELESS NETWORKS**

(75) Inventor: **Staffan Sjödin**, Stockholm (SE)

(73) Assignee: **Telefonaktiebolaget LM Ericsson (publ)**, Stockholm (SE)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/015,864**

(22) Filed: **Jan. 29, 1998**

(51) **Int. Cl.**[7] **H04Q 7/38**
(52) **U.S. Cl.** **370/469**; 370/338
(58) **Field of Search** 455/433, 436, 455/438, 439, 442, 444, 432; 370/328, 401, 469, 338; 379/59

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,040,177 A		8/1991	Martin et al.	370/110.1
5,260,987 A		11/1993	Mauger	379/58
5,289,179 A		2/1994	Beeson, Jr. et al.	340/826
5,313,461 A		5/1994	Ahl et al.	370/94.2
5,315,636 A		5/1994	Patel	379/58
5,319,699 A		6/1994	Kerihuel et al.	379/58
5,325,362 A		6/1994	Aziz	370/94.3
5,329,573 A		7/1994	Chang et al.	379/58
5,333,178 A		7/1994	Norell	379/59
5,353,331 A		10/1994	Emery et al.	379/58
5,388,101 A		2/1995	Dinkins	370/95.1
5,396,539 A		3/1995	Slekys et al.	379/59
5,396,543 A		3/1995	Beeson, Jr. et al.	379/59
5,457,680 A	*	10/1995	Kamm et al.	
5,457,736 A		10/1995	Cain et al.	379/60
5,519,691 A	*	5/1996	Darcie et al.	
5,521,961 A	*	5/1996	Fletcher et al.	379/59
5,528,668 A		6/1996	Aihara	379/60
5,530,693 A		6/1996	Averbuch et al.	370/60
5,533,026 A		7/1996	Ahmadi et al.	370/94.1
5,533,114 A		7/1996	Ballard et al.	379/220
5,546,443 A		8/1996	Raith	379/59
5,548,586 A		8/1996	Kito et al.	370/60
5,555,553 A		9/1996	Jonsson	379/214
5,563,939 A		10/1996	La Porta et al.	379/220
5,566,225 A	*	10/1996	Haas	379/58
5,583,914 A		12/1996	Chang et al.	379/58
5,590,133 A		12/1996	Billström et al.	370/349
5,608,780 A	*	3/1997	Gerszberg	379/58
5,610,972 A		3/1997	Emery et al.	379/58
5,627,829 A	*	5/1997	Gleeson et al.	370/230
5,629,974 A		5/1997	Rajala et al.	379/58
5,664,005 A		9/1997	Emery et al.	455/422
5,768,509 A	*	6/1998	Gunluk	395/200.33
5,774,695 A	*	6/1998	Autrey et al.	395/500
5,793,762 A	*	8/1998	Penners	
5,826,186 A	*	10/1998	Mitchell et al.	455/410
5,852,660 A	*	12/1998	Lindquist et al.	379/230
5,910,946 A	*	6/1999	Csapa	370/328
5,933,784 A	*	8/1999	Gallagher et al.	455/552
6,011,803 A	*	1/2000	Bicknell et al.	370/467
6,018,515 A	*	1/2000	Sorber	370/229

FOREIGN PATENT DOCUMENTS

EP	0505106	9/1992	H04Q/7/04
EP	0748136	12/1996	H04Q/7/22
FR	2697390	4/1994	H04B/7/26
WO	9533348	12/1995	H04Q/7/24
WO	9535007	12/1995	H04Q/7/38

OTHER PUBLICATIONS

Ericsson Infocom AB 1996; EIN/M–96:175C; *Portable SS7 TCAP.*

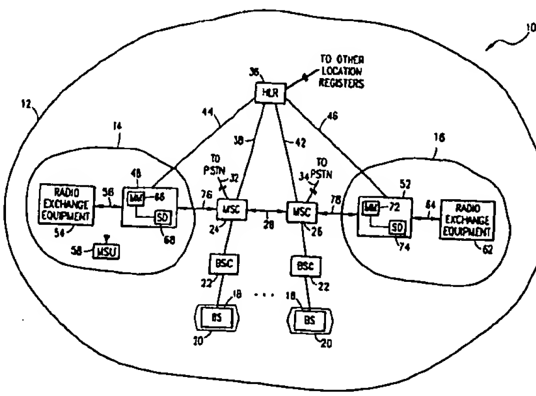
(List continued on next page.)

Primary Examiner—Kenneth Vanderpuye

(57) **ABSTRACT**

A plurality of client applications in respective microcellular communication networks communicate with a server in a macrocellular communication network via a shared communications protocol layer.

34 Claims, 20 Drawing Sheets



OTHER PUBLICATIONS

International Telecommunication Union, ITU–T Telecommunication Standardization Sector of ITU; ITU–T Recommendation Q701, 3/93; Specifications of Signalling System No. 7; *Functional Description of the Message Transfer Part (MTP) of Signalling System No. 7*; pp. 1–20.

International Telecommunication Union, ITU–T Telecommunication Standardization Sector of ITU; ITU–T Recommendation Q700, 3/93; Specifications of Signalling System No. 7; *Introduction to CCITT Signalling System No. 7*; pp. 1–20.

International Telecommunication Union, ITU–T Telecommunication Standardization Sector of ITU; ITU–T Recommendation Q771, 3/93; Specifications of Signalling System No. 7; *Signalling System No. 7—Functional Description of Transaction Capabilities*; pp. 1–33.

International Telecommunication Union, ITU–T Telecommunication Standardization Sector of ITU; ITU–T Recommendation Q772, 3/93; Specfications of Signalling System No. 7; *Signalling System No. 7—Transaction Capabilities Information Element Definitions*; pp. 1–7.

International Telecommunication Union, ITU–T Telecommunication Standardization Sector of ITU; ITU–T Recommendation Q773, 3/93; Specifications of Signalling System No. 7; *Signalling System No. 7—Transaction Capabilities Formats and Encoding*; pp. 1–33.

International Telecommunication Union, ITU–T Telecommunication Standardization Sector of ITU; ITU–T Recommendation Q774, 3/93; Specifications of Signalling System No. 7; *Signalling System No. 7—Transaction Capabilities Procedures*; pp. 1–60.

International Telecommunication Union, ITU–T Telecommunication Standardization Sector of ITU; ITU–T Recommendation Q775, 3/93; Specifications of Signalling System No. 7; *Signalling System No. 7—Guidelines for Using Transaction Capabilities*; pp. 1–34.

International Telecommunication Union, ITU–T Telecommunication Standardization Sector of ITU; ITU–T Recommendation Q711, 7/96, Series Q: Switching and Signalling, Specifications of Signalling System No. 7—Signalling Connection Control Part; *Functional Description of the Signalling Connnection Control Part*; pp. 1–32.

* cited by examiner

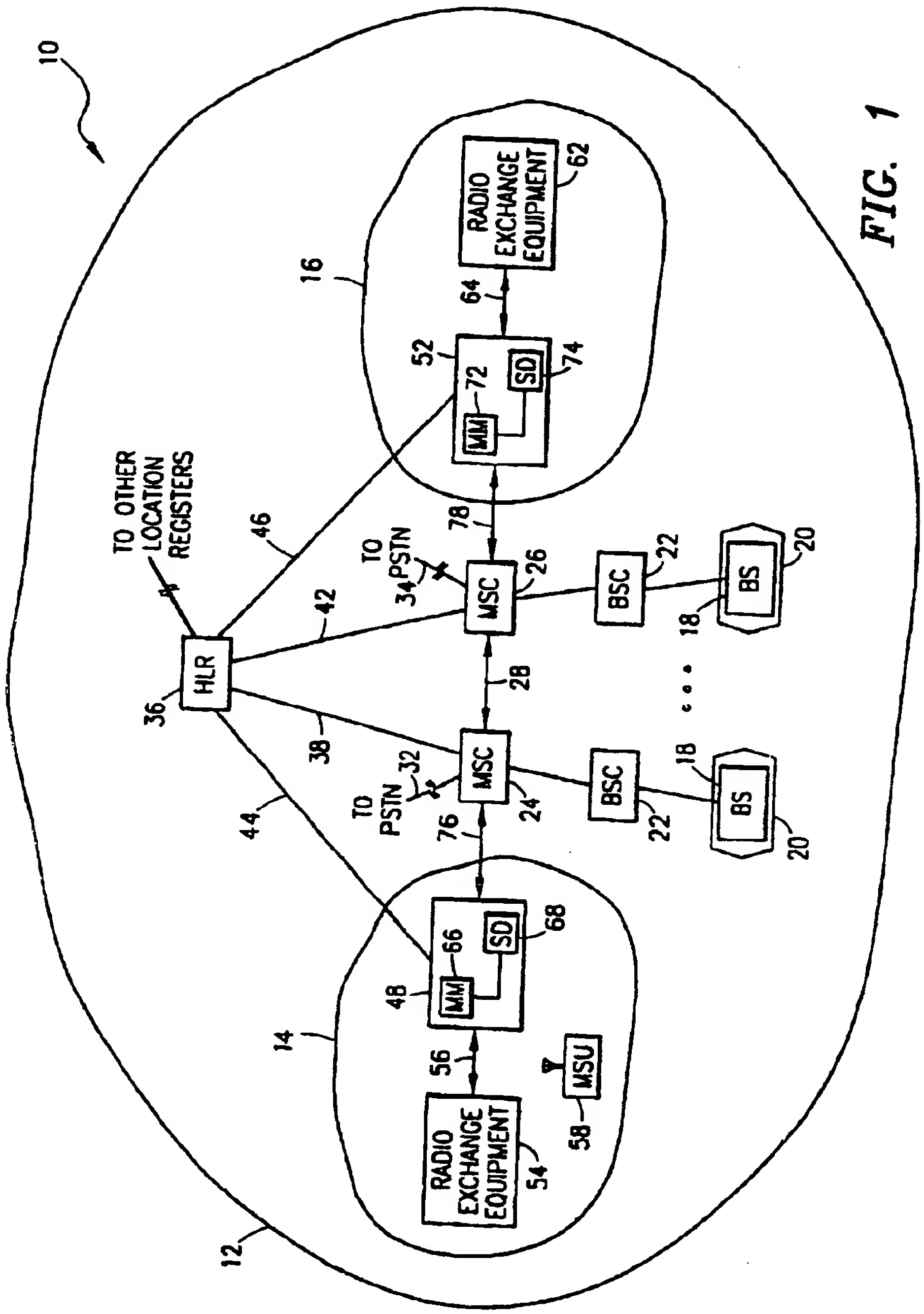

TO OTHER LOCATION REGISTERS
HLR
MSC
MSC
TO PSTN
TO PSTN
BSC
BSC
BS
BS
MM
SD
MM
SD
RADIO EXCHANGE EQUIPMENT
RADIO EXCHANGE EQUIPMENT
MSU

FIG. 1

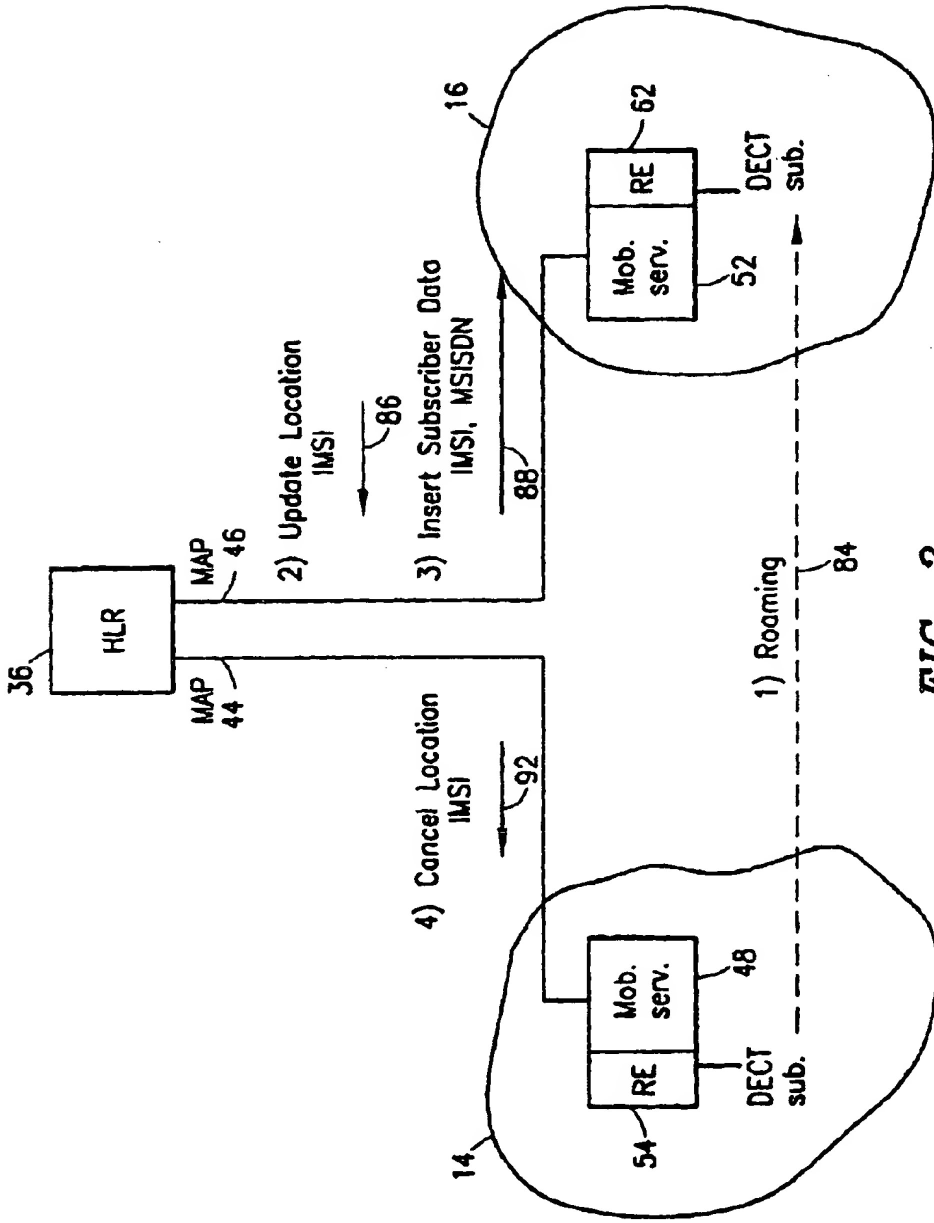

HLR
36
MAP 46
MAP 44
2) Update Location
IMSI
86
3) Insert Subscriber Data
IMSI, MSISDN
88
4) Cancel Location
IMSI
92
1) Roaming
84
16
Mob. serv.
52
RE
62
DECT sub.
14
Mob. serv.
48
RE
54
DECT sub.

FIG. 2

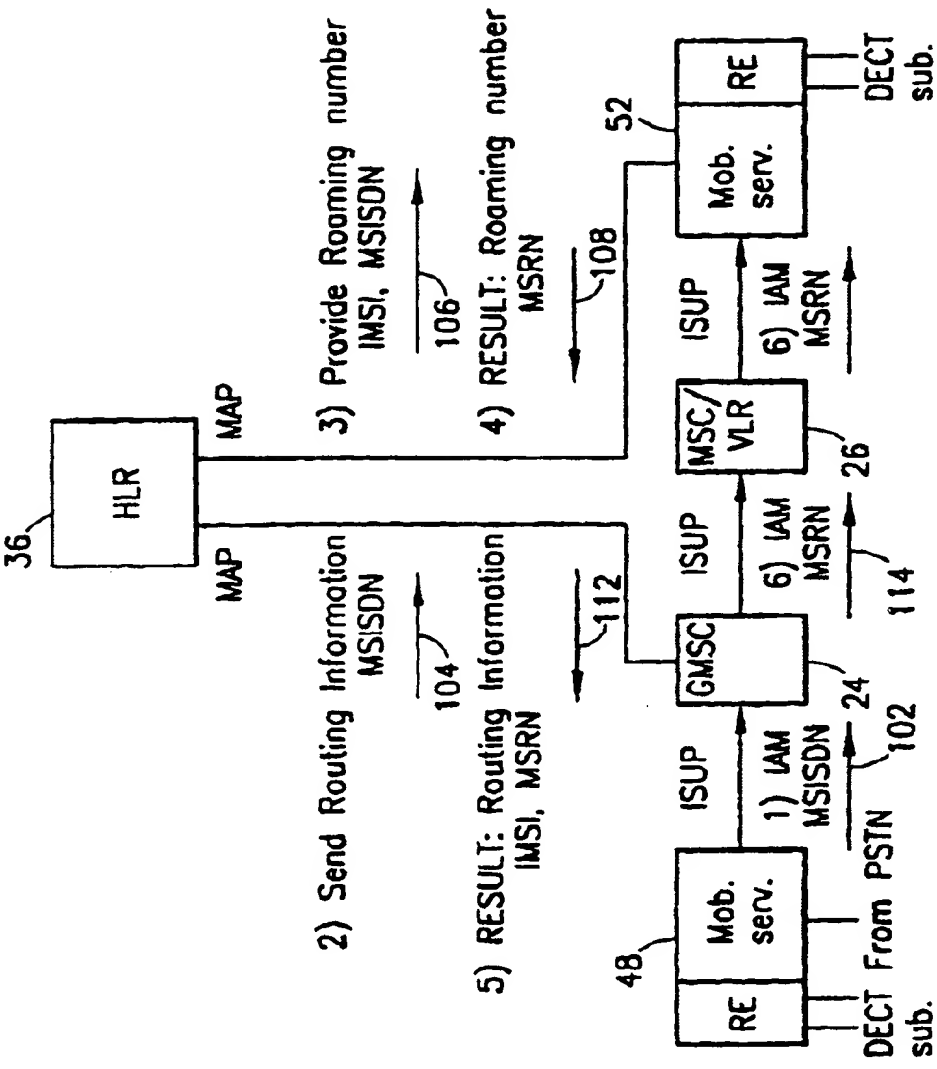

HLR
36
MAP
MAP
2) Send Routing Information
MSISDN
104
3) Provide Roaming number
IMSI, MSISDN
106
4) RESULT: Roaming number
MSRN
108
5) RESULT: Routing Information
IMSI, MSRN
112
RE
Mob. serv.
48
DECT sub.
From PSTN
ISUP
1) IAM
MSISDN
102
GMSC
24
ISUP
6) IAM
MSRN
114
MSC/ VLR
26
ISUP
6) IAM
MSRN
Mob. serv.
RE
52
DECT sub.

FIG. 3

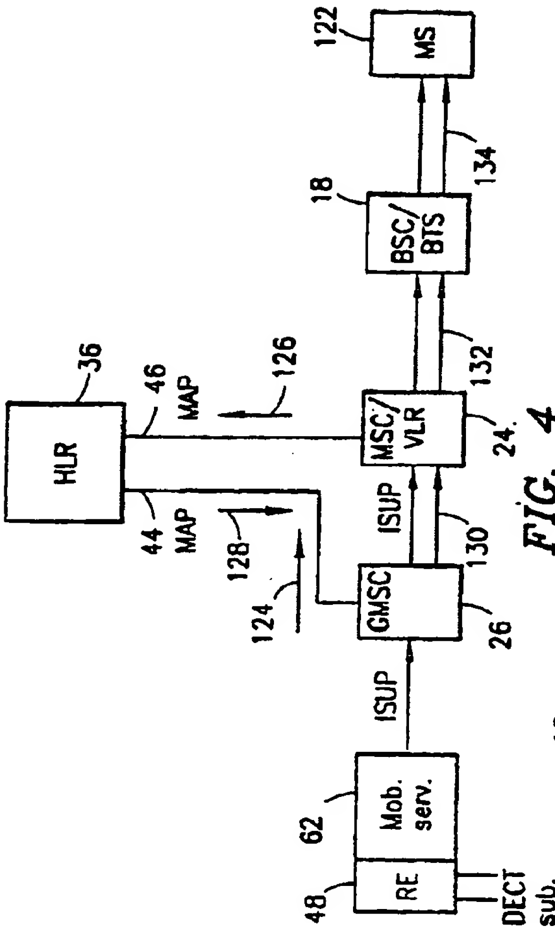

HLR
36
46
MAP
126
44
MAP
128
124
MSC/
VLR
24
ISUP
130
132
BSC/
BTS
18
134
MS
122
GMSC
26
ISUP
Mob.
serv.
62
RE
48
DECT
sub.

FIG. 4

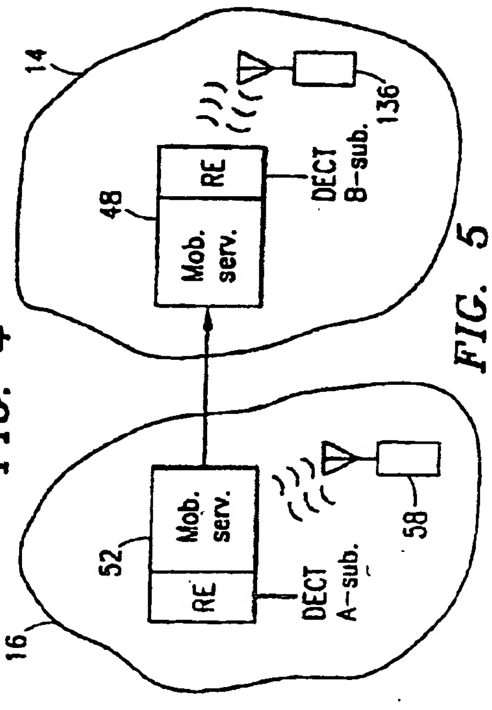

14
Mob.
serv.
RE
48
DECT
B-sub.
136
16
Mob.
serv.
52
RE
DECT
A-sub.
58

FIG. 5

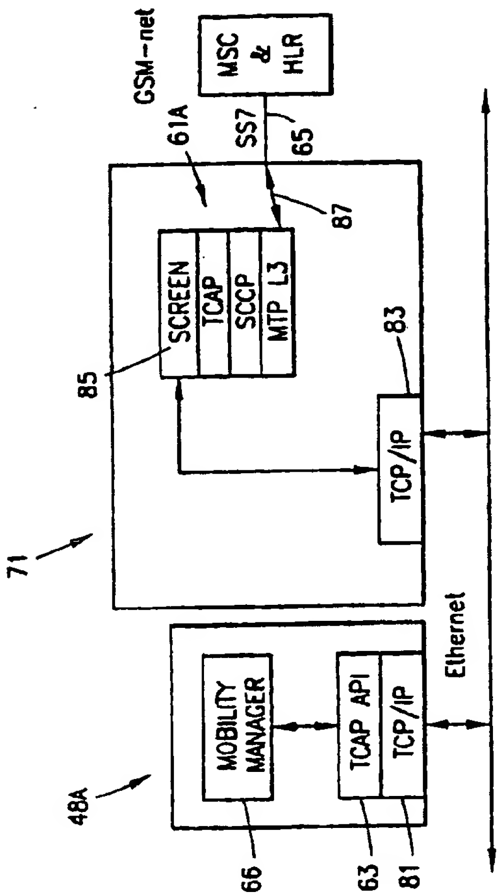


FIG. 8

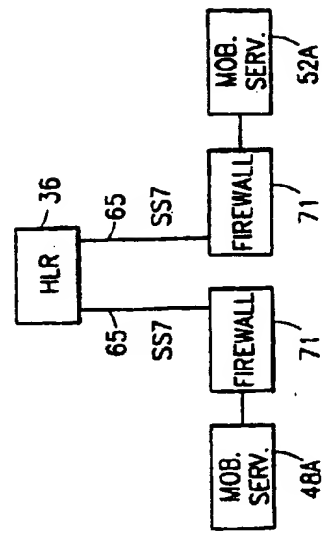


FIG. 7

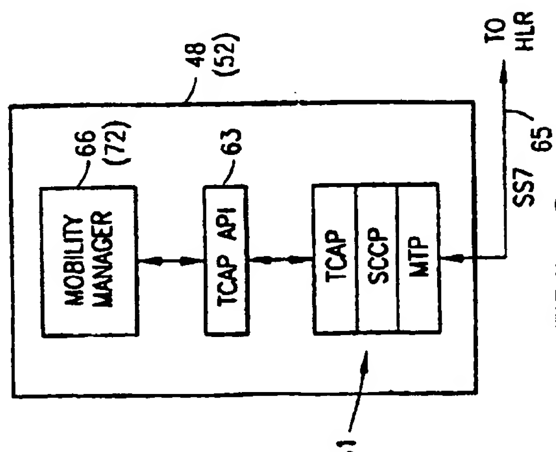


FIG. 6

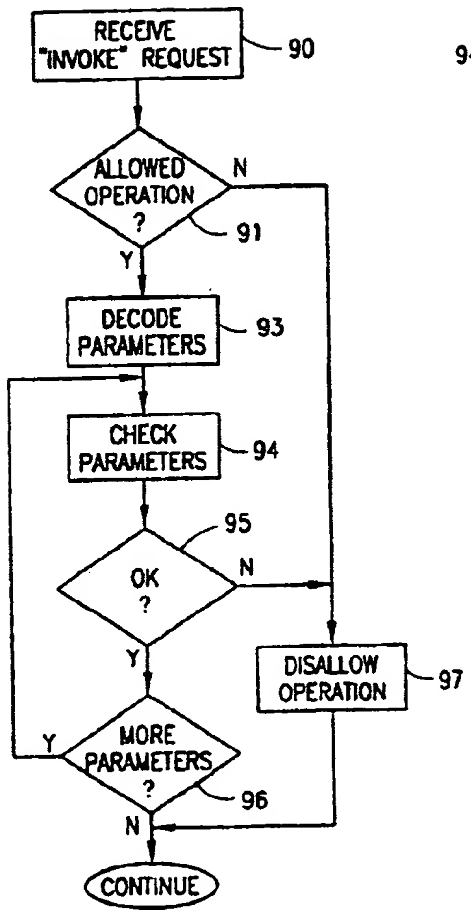

RECEIVE "INVOKE" REQUEST
90
ALLOWED OPERATION ?
N
Y
91
DECODE PARAMETERS
93
CHECK PARAMETERS
94
95
OK ?
N
Y
DISALLOW OPERATION
97
Y
MORE PARAMETERS ?
96
N
CONTINUE

FIG. 9

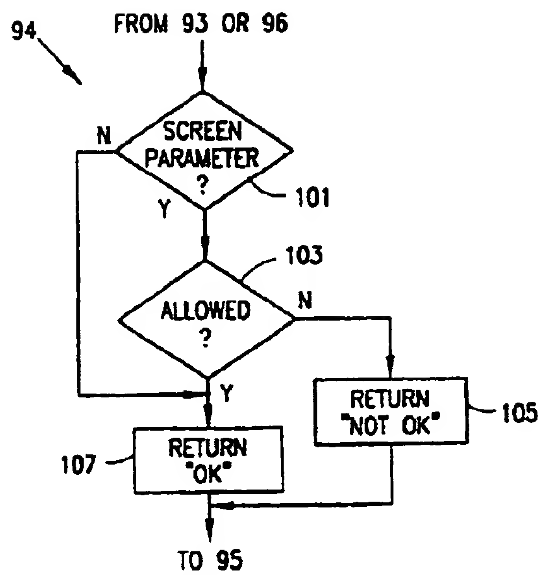

94
FROM 93 OR 96
SCREEN PARAMETER ?
N
Y
101
103
ALLOWED ?
N
Y
RETURN "NOT OK"
105
107
RETURN "OK"
TO 95

FIG. 10

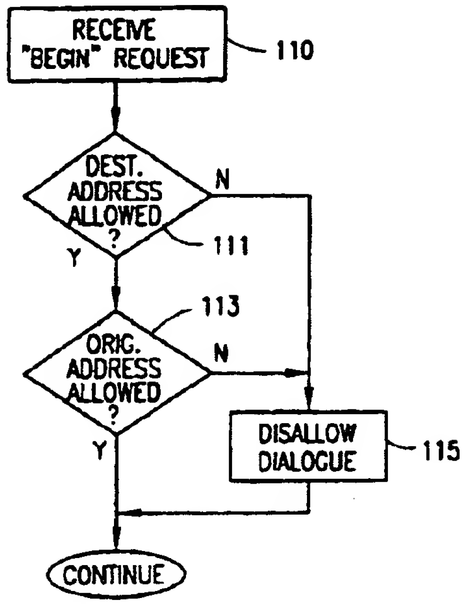


FIG. 11

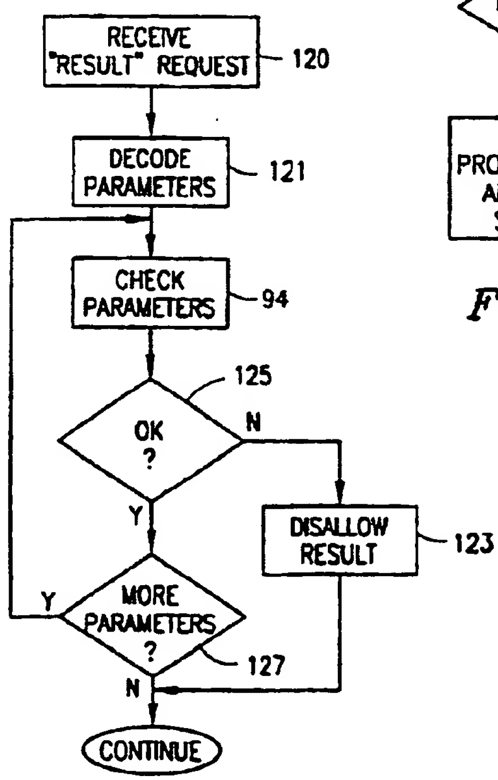


FIG. 12

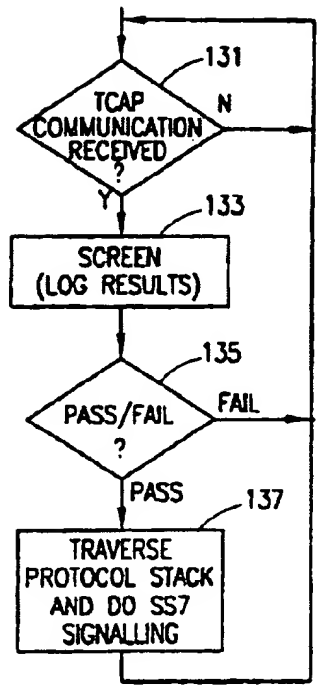


FIG. 13

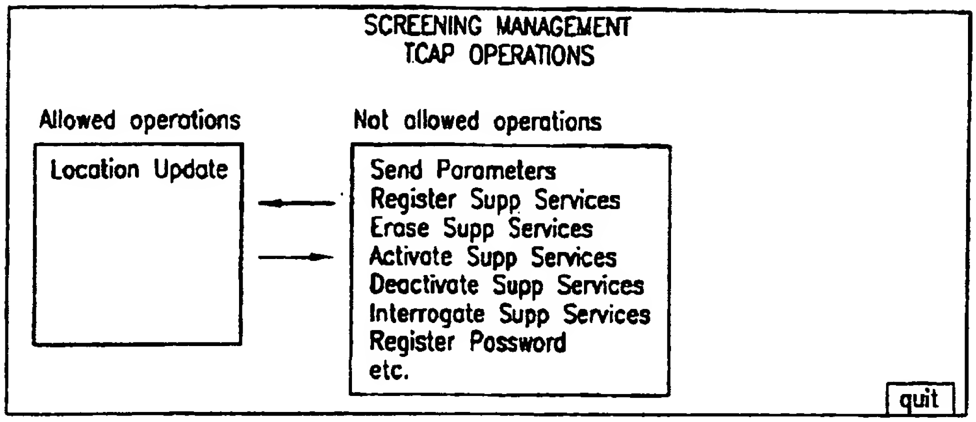

SCREENING MANAGEMENT
TCAP OPERATIONS
Allowed operations
Location Update
Not allowed operations
Send Parameters
Register Supp Services
Erase Supp Services
Activate Supp Services
Deactivate Supp Services
Interrogate Supp Services
Register Password
etc.
quit

FIG. 14

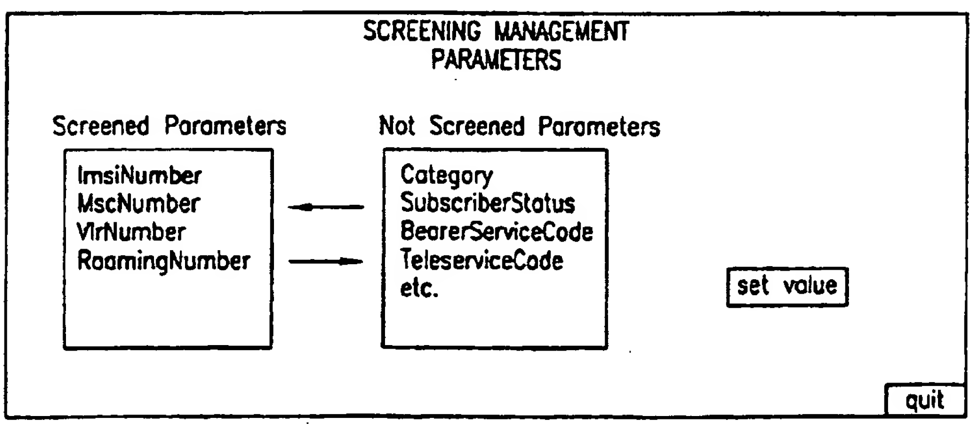

SCREENING MANAGEMENT
PARAMETERS
Screened Parameters
ImsiNumber
MscNumber
VlrNumber
RoamingNumber
Not Screened Parameters
Category
SubscriberStatus
BearerServiceCode
TeleserviceCode
etc.
set value
quit

FIG. 15

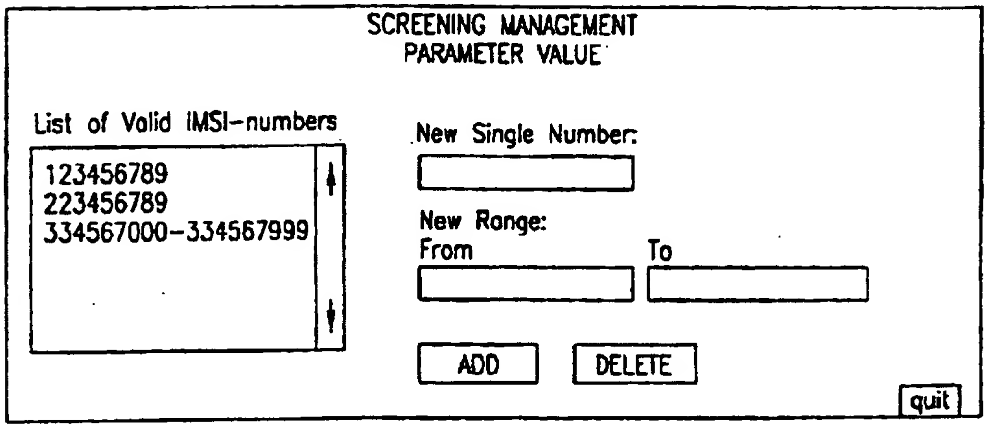

SCREENING MANAGEMENT
PARAMETER VALUE
List of Valid IMSI-numbers
123456789
223456789
334567000-334567999
New Single Number:
New Range:
From
To
ADD
DELETE
quit

FIG. 16

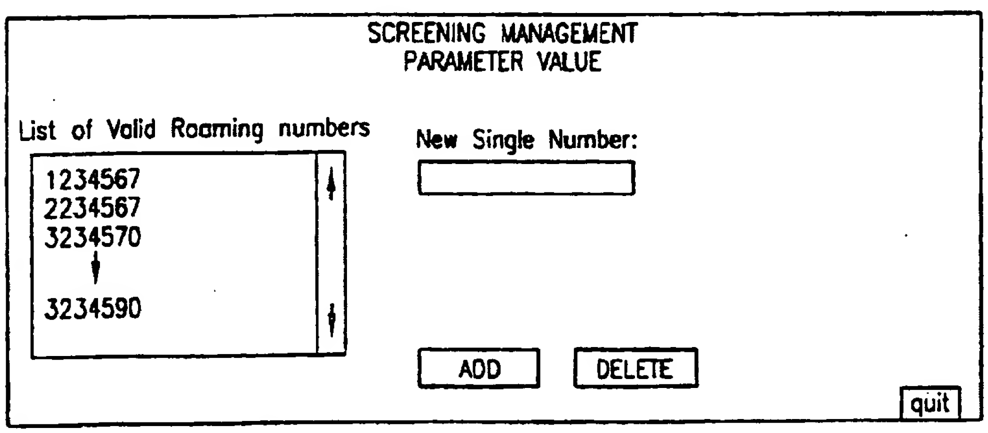

SCREENING MANAGEMENT
PARAMETER VALUE
List of Valid Roaming numbers
1234567
2234567
3234570
3234590
New Single Number:
ADD
DELETE
quit

FIG. 17

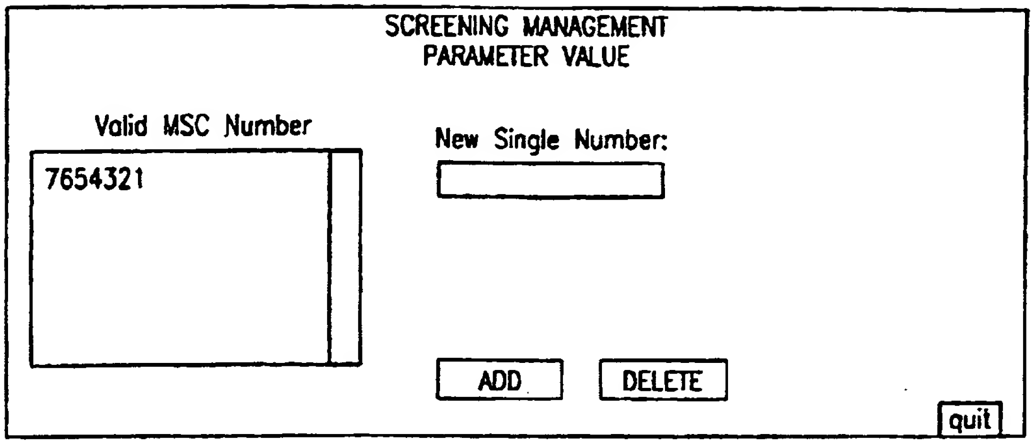

SCREENING MANAGEMENT
PARAMETER VALUE
Valid MSC Number
7654321
New Single Number:
ADD
DELETE
quit

FIG. 18

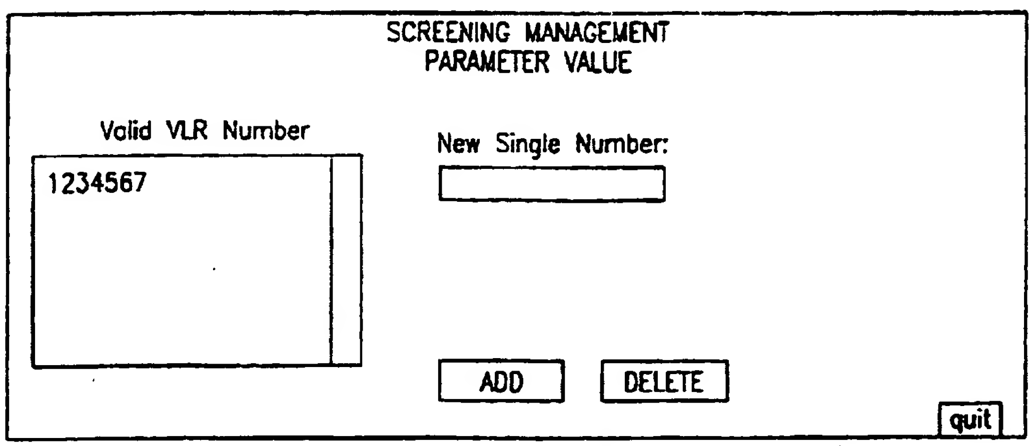

SCREENING MANAGEMENT
PARAMETER VALUE
Valid VLR Number
1234567
New Single Number:
ADD
DELETE
quit

FIG. 19

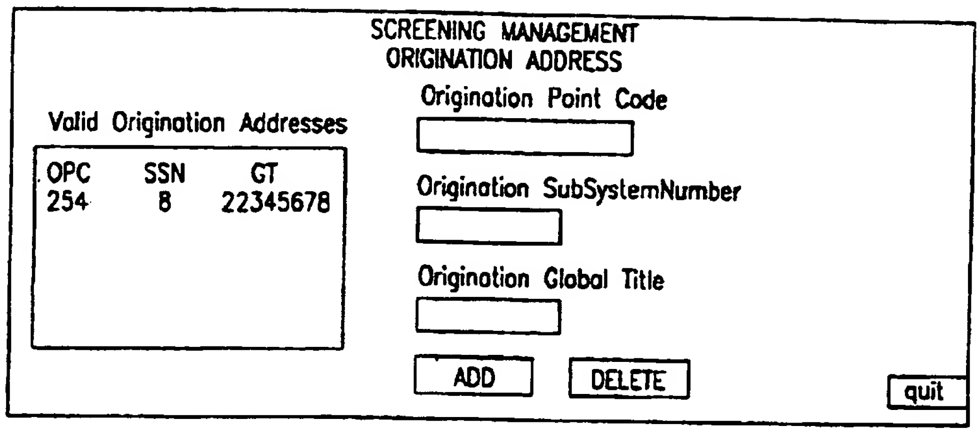

SCREENING MANAGEMENT
ORIGINATION ADDRESS
Valid Origination Addresses
OPC SSN GT
254 8 22345678
Origination Point Code
Origination SubSystemNumber
Origination Global Title
ADD
DELETE
quit

FIG. 20

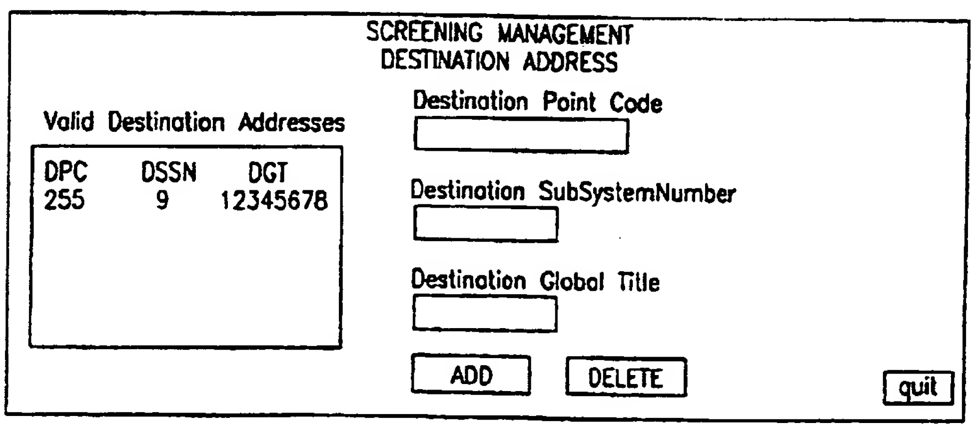

SCREENING MANAGEMENT
DESTINATION ADDRESS
Valid Destination Addresses
DPC DSSN DGT
255 9 12345678
Destination Point Code
Destination SubSystemNumber
Destination Global Title
ADD
DELETE
quit

FIG. 21

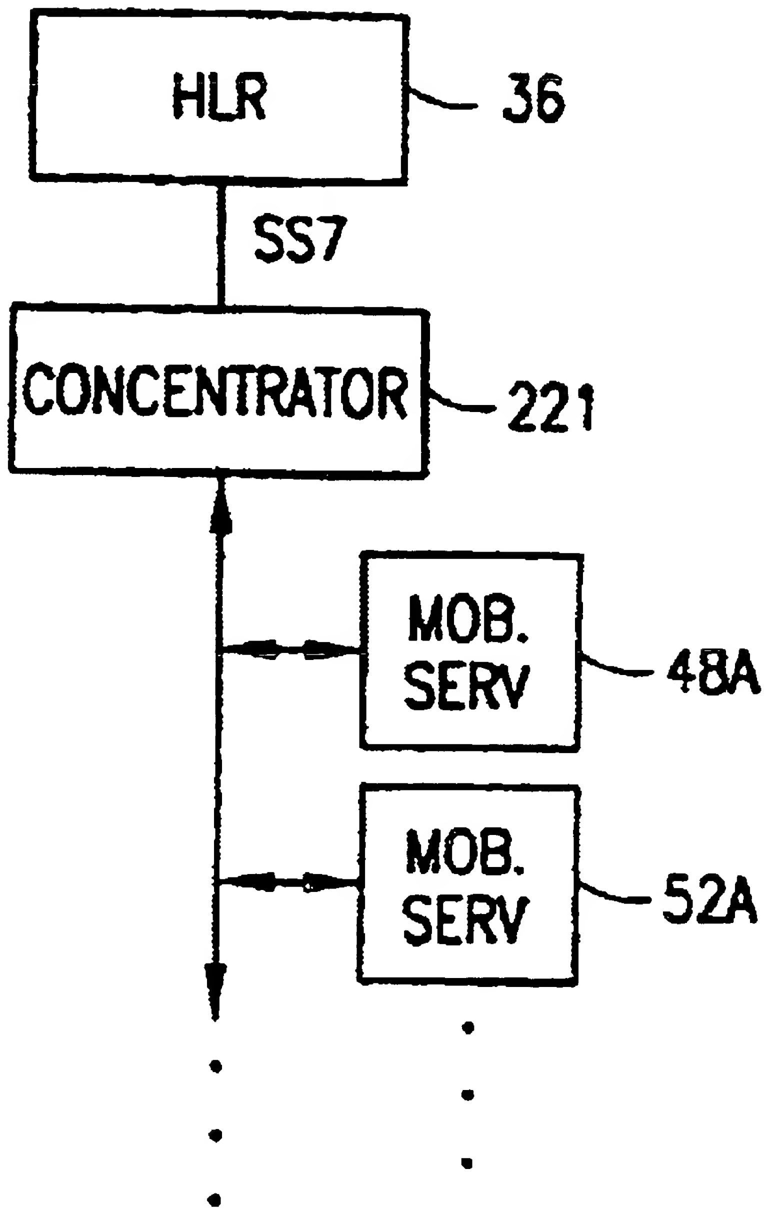


FIG. 22

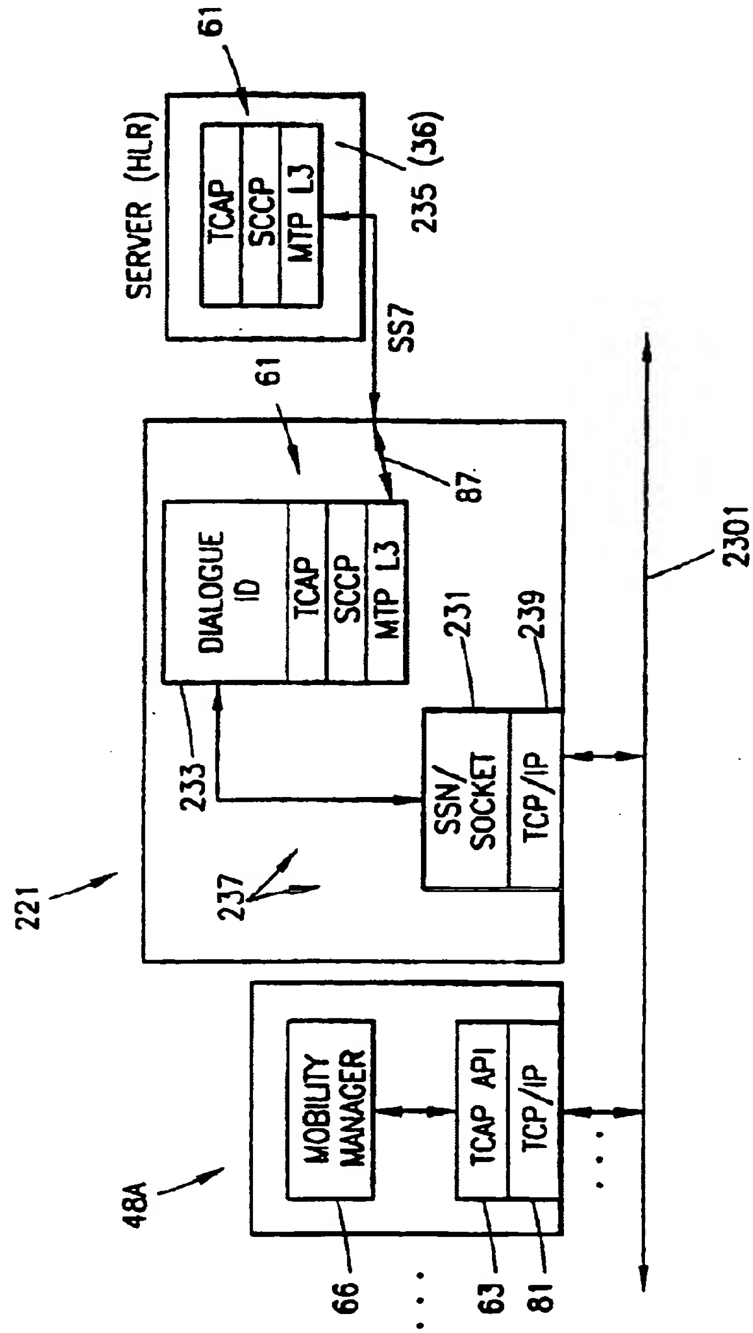

SERVER (HLR)
TCAP
SCCP
MTP L3
61
235 (36)
SS7
61
87
DIALOGUE ID
TCAP
SCCP
MTP L3
2301
231
239
SSN/ SOCKET
TCP/IP
233
237
221
MOBILITY MANAGER
TCAP API
TCP/IP
48A
66
63
81

FIG. 23

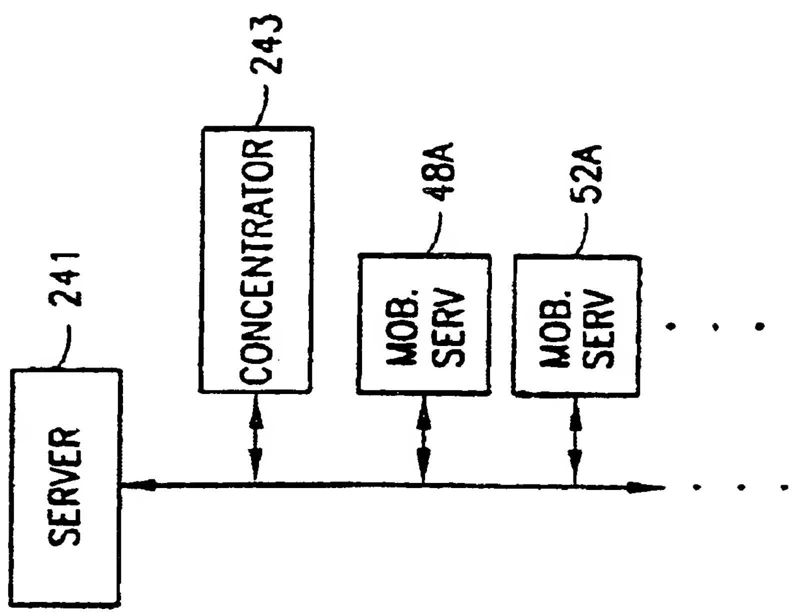


FIG. 24

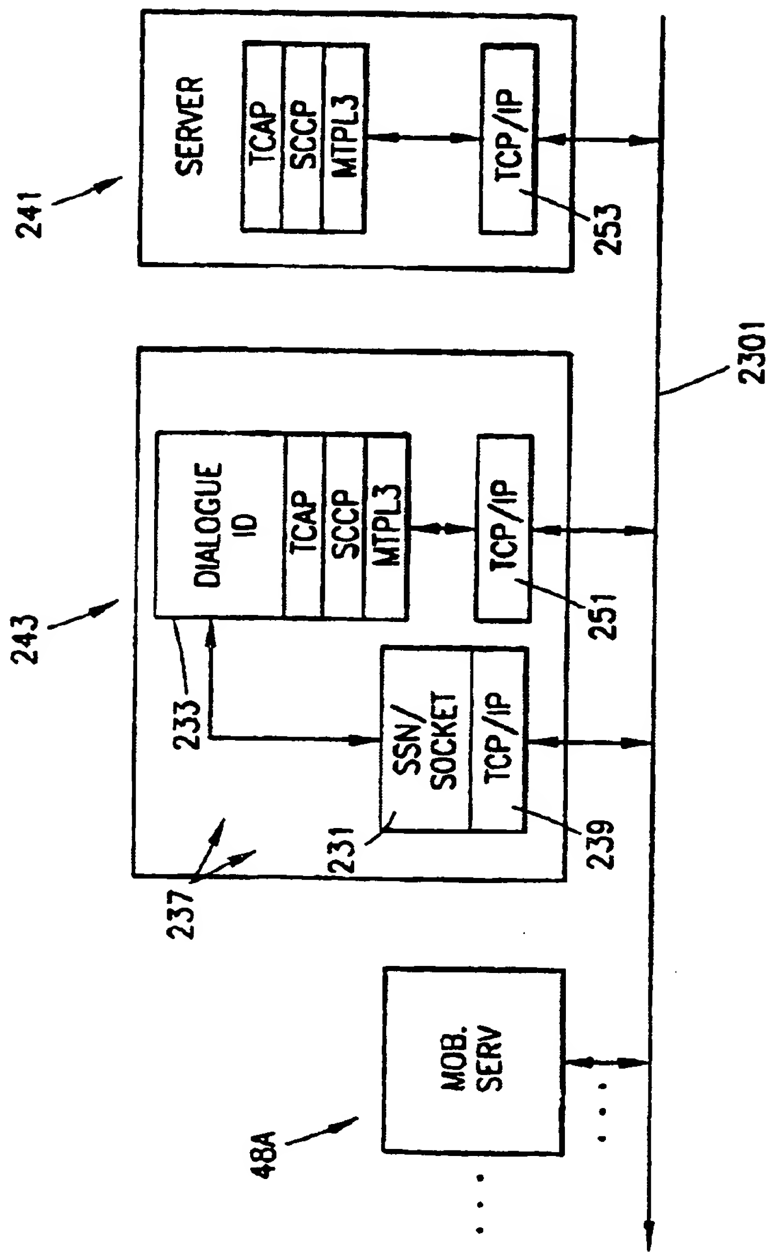

241
SERVER
TCAP
SCCP
MTPL3
TCP/IP
253
243
DIALOGUE ID
TCAP
SCCP
MTPL3
TCP/IP
251
2301
233
SSN/ SOCKET
TCP/IP
231
239
237
48A
MOB. SERV

FIG. 25

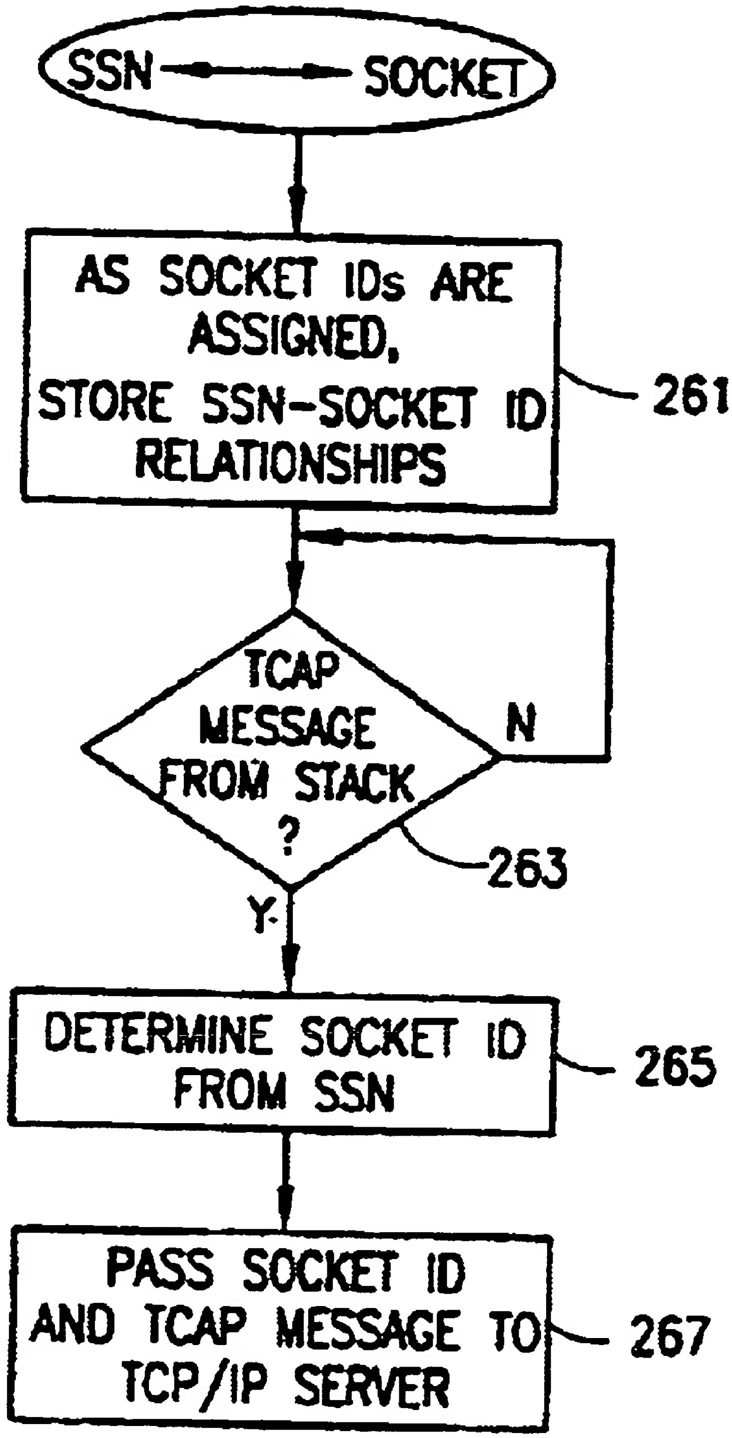

SSN SOCKET
AS SOCKET IDs ARE ASSIGNED, STORE SSN-SOCKET ID RELATIONSHIPS
261
TCAP MESSAGE FROM STACK ?
N
Y
263
DETERMINE SOCKET ID FROM SSN
265
PASS SOCKET ID AND TCAP MESSAGE TO TCP/IP SERVER
267

FIG. 26

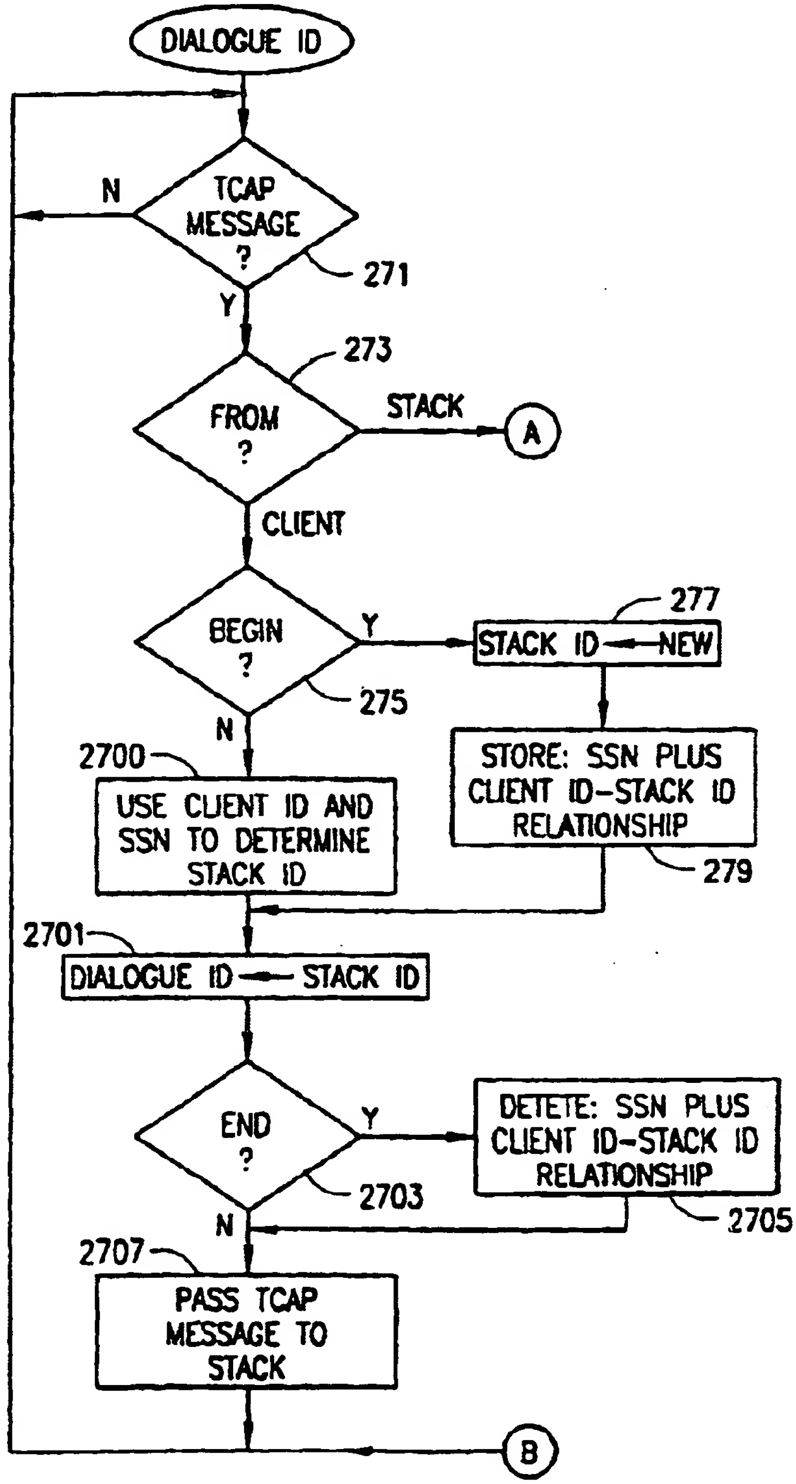

DIALOGUE ID
TCAP MESSAGE ?
N
Y
271
273
FROM ?
STACK
A
CLIENT
BEGIN ?
Y
277
STACK ID ← NEW
275
N
2700
USE CLIENT ID AND SSN TO DETERMINE STACK ID
STORE: SSN PLUS CLIENT ID-STACK ID RELATIONSHIP
279
2701
DIALOGUE ID ← STACK ID
END ?
Y
DETETE: SSN PLUS CLIENT ID-STACK ID RELATIONSHIP
2703
2705
N
2707
PASS TCAP MESSAGE TO STACK
B

FIG. 27

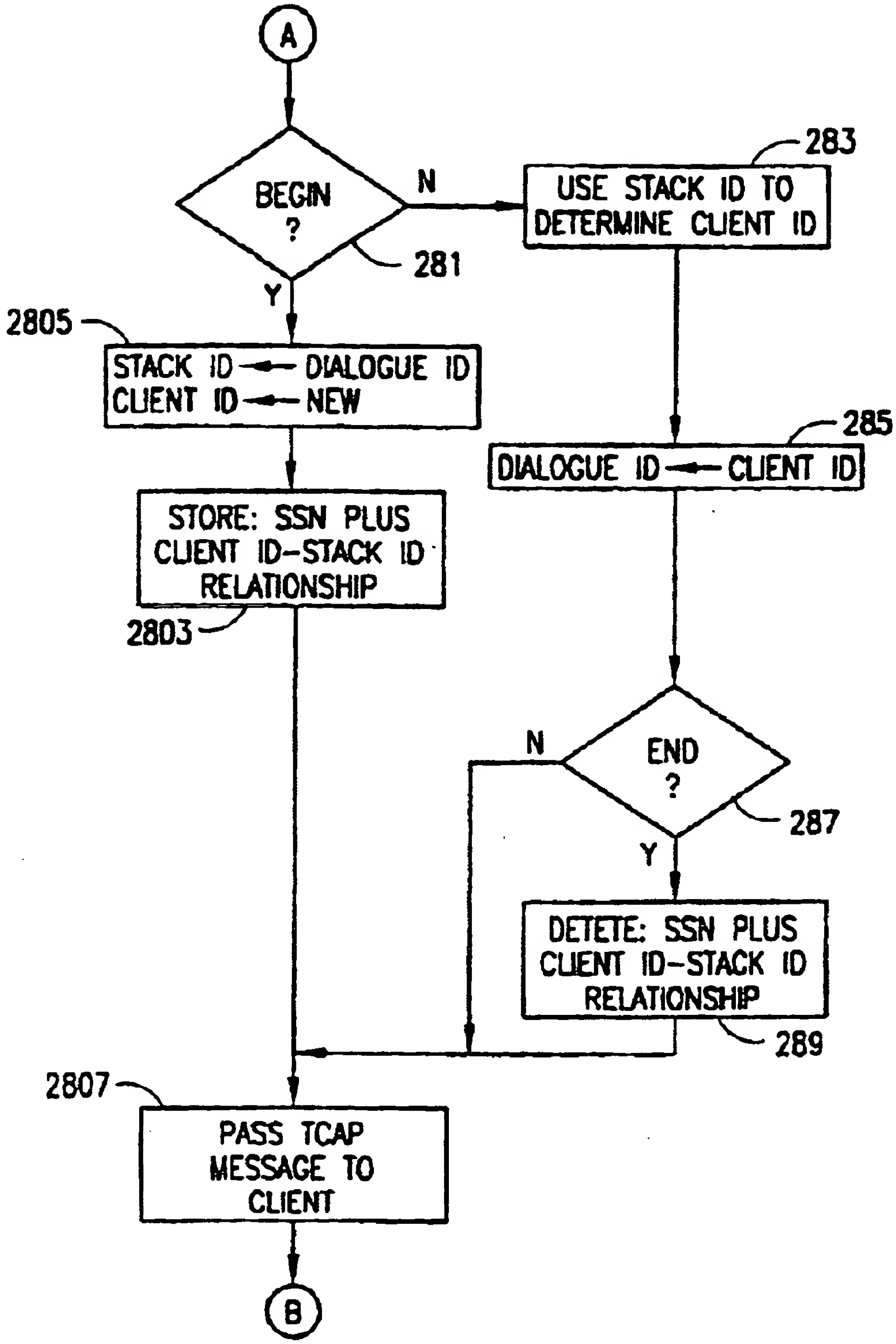

A
BEGIN ?
N
Y
281
283
USE STACK ID TO DETERMINE CLIENT ID
2805
STACK ID ← DIALOGUE ID
CLIENT ID ← NEW
285
DIALOGUE ID ← CLIENT ID
STORE: SSN PLUS CLIENT ID–STACK ID RELATIONSHIP
2803
END ?
N
Y
287
DETETE: SSN PLUS CLIENT ID–STACK ID RELATIONSHIP
289
2807
PASS TCAP MESSAGE TO CLIENT
B

FIG. 28

DIALOGUE ID DATABASE

SSN	CLIENT ID	STACK ID
10	C1	S1
20	C2	S2
30	C3	S3
•	•	•
•	•	•
•	•	•

FIG. 29

SSN ←→ SOCKET DATABASE

SSN	SOCKET ID
10	K1
20	K2
30	K3
•	•
•	•
•	•

FIG. 30

SSN	LAST CLIENT ID
10	378
11	78
12	379
.	.
.	.
.	.

FIG. 31

LAST STACK ID
765

FIG. 32

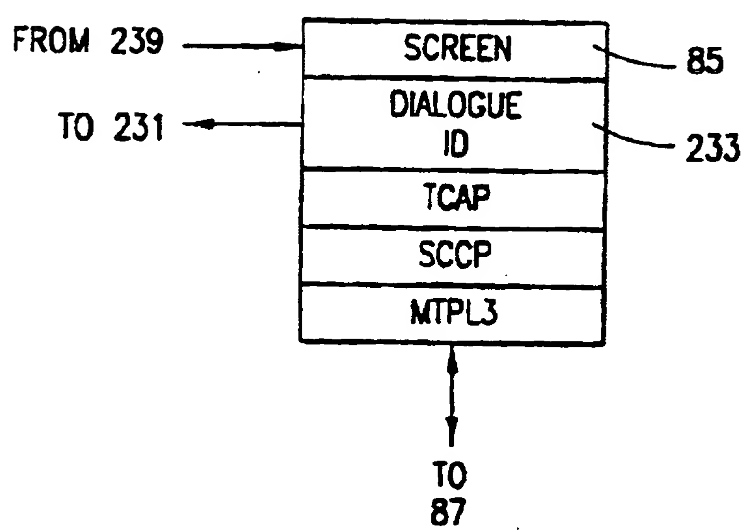


FIG. 33

SHARED COMMUNICATIONS PROTOCOL LAYER FOR INTERFACING BETWEEN WIRELESS NETWORKS

CROSS-REFERENCE TO RELATED APPLICATION

The subject matter of the present application is related to subject matter disclosed in U.S. Ser. No. 08/680,225 filed on Jul. 11, 1996.

FIELD OF THE INVENTION

This invention relates to communications between wireless networks and, more particularly, to interfaces controlling communications between wireless networks.

BACKGROUND OF THE INVENTION

Advancements in the fields of electronics and communications have permitted the introduction and commercialization of many new types of communication systems. Information can be affordably communicated to locations and in manners previously not possible or affordable.

The field of cellular telephony is exemplary of a communication system that has been made possible due to such advancements. A fixed, wireline connection is not required between a transmitting station and a receiving station in a cellular, or other radiotelephonic, communication system to effectuate communications between the stations. Because a "wireless" connection is formed between the transmitting station and the receiving station, use of such a communication system is particularly advantageous to effectuate communications when a wireline connection cannot be conveniently or practically formed.

Various different types of cellular, and other radiotelephonic, communication systems have been implemented and others have been proposed. In many parts of the world, for instance, macrocellular communication networks have been installed. Such networks permit mobile subscriber units positioned anywhere within the area encompassed by the macrocellular networks to communicate pursuant to the macrocellular communication network. A macrocellular communication network typically includes a large number of base stations positioned at spaced-apart locations throughout a geographic area. As a mobile subscriber unit moves throughout the geographical area, communications with the mobile subscriber unit are "handed-off" to successive ones of the base stations. In one type of cellular communication system, a Global System for Mobile (GSM) communications system, control circuitry, including mobile services switching centers (MSCs) and base stations controllers (BSCs), controls communications between the base stations and the mobile subscriber unit. And, location registers, including a home location register (HLR) associated with the mobile subscriber unit, maintain a registry of the positioning of the mobile subscriber unit in a network.

Microcellular communication networks have also been developed and implemented. A Digital Electronic Cordless Telephone (DECT) system is exemplary of a microcellular communication network. A microcellular communication network, analogous to a macrocellular communication network, also permits wireless communications to be effectuated with a mobile subscriber unit. The area encompassed by a microcellular communication network is, however, typically much smaller than the area encompassed by a macrocellular communication network.

The costs associated with a microcellular communication network are generally less than the costs associated with a macrocellular communication network. However, because microcellular communication networks generally encompass limited areas, a single business, or other operator, might be required to construct more than one microcellular communication network to encompass a desired area in which microcellular communications are to be permitted.

For instance, a microcellular communication network might be constructed to provide microcellular communication coverage encompassing a single building. A mobile subscriber unit regularly registered to communicate pursuant to the microcellular communication network must be within the building, i.e., the area encompassed by the microcellular communication network, to communicate therethrough.

It is sometimes desirable to permit a mobile subscriber unit, regularly registered in one microcellular communication network (the "home" network), also to communicate in another microcellular communication network (the "visited" network). For instance, a business might have separate office locations, requiring separate microcellular networks to be installed for each of the separate office locations. It is sometimes desirable, in such instances, to permit personnel regularly located at one of the office locations to be able to communicate by way of a microcellular communication network even when the personnel are temporarily positioned at the other one of the office locations.

By providing communication links between the separate microcellular networks, registration, and other, information pertaining to the mobile subscriber unit stored at the "home" microcellular communication network can be used to permit communications with the mobile subscriber unit, even when the mobile subscriber unit is positioned in an area encompassed by the "visited" microcellular communication network.

Various proposals have been set forth to form communication links between microcellular networks by way of a macrocellular communication network. Such proposals, however, have generally been set forth for purposes of call control and not for purposes of mobility management. Viz. existing proposals for intercoupling the networks have not generally pertained to providing wide-area mobility to mobile subscriber units of microcellular communication networks.

Additionally, existing proposals generally require direct connections between the microcellular and macrocellular communication networks. As the operators of the macrocellular and microcellular communication networks might well be different entities, the conventional requirement for direct connections between the microcellular communication networks might sometimes be problematical.

A manner by which better to provide wide-area mobility to a mobile subscriber unit to increase the mobility permitted of the mobile subscriber unit would be advantageous.

Additionally, a manner by which to provide for the communication of mobility management information between a microcellular and macrocellular communication network without requiring direct connections therebetween would also be advantageous.

It is in light of this background information related to mobility management in a cellular communication system that the significant improvements of the present invention have evolved.

SUMMARY OF THE INVENTION

The present invention advantageously provides a method, and associated apparatus, for facilitating communications to

and from a mobile subscriber unit operable in a microcellular communication network when the mobile subscriber unit roams into an area encompassed by a "visited" microcellular communication network other than the "home" network in which the mobile subscriber unit is regularly registered.

Wide-area mobility management functions available in a macrocellular network are provided to microcellular networks by coupling the microcellular networks to the macrocellular network. Wide-area mobility is thereby provided to a mobile subscriber unit operable in a microcellular communication network. The wide-area management functions provided to the microcellular communication network permits a mobile subscriber unit to communicate by way of a microcellular communication network even when it roams into an area encompassed by a "visited" network.

When the macrocellular communication network is formed of a Global System for Mobile communications (GSM) network, the microcellular communication networks include the mobility servers which appear, to the GSM network, to be mobile services switching centers (MSCs) of the GSM network. Mobility management normally provided to the mobile services switching centers of the GSM network are provided to the mobility servers of the microcellular networks. Signaling between the mobility server and the macrocellular communication network permits, for example, calls to be placed to and from a mobile subscriber unit when the subscriber unit roams beyond the microcellular communication network in which the subscriber unit is regularly registered. Location updating of the position at which the subscriber unit roams is similarly also effectuated.

In one aspect of the present invention, location information related to the position of a mobile subscriber unit is updated when the, mobile subscriber unit roams into an area encompassed by a microcellular communication network other than the network in which the subscriber unit is regularly registered. A mobility server of such "visited" microcellular network receives indications of the positioning of the subscriber unit and provides information indicative thereof to a home location register (HLR) of the macrocellular communication network. The home location register (HLR) provides the visited mobility server with subscriber data related to the mobile subscriber unit and orders the "home" mobility server of the subscriber unit's home network to deregister the subscriber unit therefrom.

In another aspect of the present invention, calls originated at a Public Switched Telephone Network (PSTN) to be terminated to a mobile subscriber unit of the "home" microcellular communication network are routed to the subscriber unit when the subscriber unit roams beyond the "home" network and into a "visited" network. In one exemplary routing method, the call is routed via the home microcellular communication network to a gateway mobile services switching center (GMSC) of the macrocellular communication network, and the GMSC interrogates the home location register of the macrocellular network to obtain routing information to route the call to the roaming subscriber unit. The HLR requests and receives information from the mobility server of the "roaming" microcellular network. Such information is provided to the GMSC, and the call is routed to the mobile subscriber unit, to be terminated thereat.

In another aspect of the present invention, a call originated at a roaming, subscriber unit is routed to a subscriber unit registered in the macrocellular communication network. And, in yet another aspect of the present invention, calls are placed between a mobile subscriber unit positioned in a "home" microcellular network to a mobile subscriber unit roaming in a "visited" microcellular communication network. And, in yet another aspect of the present invention, the mobile subscriber unit forms a dual-mode subscriber unit, operable in both a microcellular network and a macrocellular network. Calls are placed, or received, by the subscriber unit when the subscriber unit is positioned in its "home" microcellular network, a visited microcellular network, or within an area encompassed only by the macrocellular network.

With respect to foregoing aspects of the present invention, the mobility management signaling entering the macrocellular network is screened to protect the functions of the macrocellular network from damage.

Further with respect to foregoing aspects of the present invention, a plurality of mobility servers communicate with a central server such as an HLR or a debit platform via a shared communications protocol layer.

In these and other aspects, therefore, mobility-enhancing apparatus for a first mobility server facilitates communication with a mobile subscriber unit. The mobile subscriber unit is operable in a first microcellular communication network of a communication system having a macrocellular communication network and at least the first microcellular communication network. The first microcellular communication network includes the first mobility server. The mobility-enhancing apparatus facilitates communication with the mobile subscriber unit, operable in the first microcellular communication network, in a communication network other than the first microcellular communication network. A storage device stores location information representative of positioning of the mobile subscriber unit. A mobility manager is coupled to the storage device and to the macrocellular network. The mobility manager at least updates the location information stored in the storage device to indicate whether the mobile subscriber unit is positioned within range of the first microcellular communication network. The mobility manager further receives macrocellular network-generated data related to the mobile subscriber unit, and the network-generated data is used for the updating of the location information.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a functional block diagram of a communication system which includes an embodiment of the present invention as a portion thereof.

FIG. 2 illustrates a functional block diagram of a portion of the communication system shown in FIG. 1 used during operation of an embodiment of the present invention to update the location of a mobile subscriber unit when the mobile subscriber unit roams into an area encompassed by a microcellular communication network other than the "home" microcellular network in which the subscriber unit is regularly registered.

FIG. 3 illustrates a functional block diagram of a portion of the communication system shown in FIG. 1 used during a call to a mobile subscriber unit that has roamed into a microcellular communication network other than the "home" network in which the subscriber unit is regularly registered.

FIG. 4 illustrates a portion of the communication system shown in FIG. 1, used during operation of an embodiment of the present invention to route a call originated by a mobile subscriber unit when the mobile subscriber unit is positioned in an area encompassed by a microcellular communication network other than the "home" network in which the subscriber unit is regularly registered.

FIG. 5 illustrates a portion of the communication system shown in FIG. 1 used during operation of an embodiment of the present invention to route a call between subscriber units positioned in different microcellular communication networks.

FIG. 6 illustrates in detail an example of a mobility signaling portion of the mobility servers of FIGS. 1–5.

FIG. 7 is a block diagram illustrating an exemplary signaling channel firewall arrangement according to the present invention.

FIG. 8 illustrates the signaling channel firewall arrangement of FIG. 7 in greater detail.

FIG. 9 illustrates the operation of one part of the screening function of FIG. 8.

FIG. 10 illustrates a portion of FIG. 9 in greater detail.

FIG. 11 illustrates the operation of another part of the screening function of FIG. 8.

FIG. 12 illustrates the operation of another part of the screening function of FIG. 8.

FIG. 13 illustrates generally the operation of the screening function of FIG. 8 with respect to the operation of the protocol stack and SS7 signaling channel of FIG. 8.

FIG. 14 illustrates an exemplary database of operations that can be screened according to the present invention.

FIG. 15 illustrates an exemplary database of parameters that can be screened according to the present invention.

FIGS. 16–19 illustrates specific values and ranges which can be defined in an exemplary parameter database according to the invention.

FIG. 20 illustrates an exemplary database for screening origination addresses according to the invention.

FIG. 21 illustrates an exemplary database for screening destination addresses according to the invention.

FIG. 22 is a block diagram which illustrates how a plurality of mobility servers communicate with HLR via a concentrator according to the present invention.

FIG. 23 illustrates the concentrator and HLR of FIG. 22 in greater detail.

FIG. 24 illustrates another arrangement according to the present invention wherein a plurality of mobility servers communicate with a central server via a concentrator.

FIG. 25 illustrates the concentrator and server of FIG. 24 in greater detail.

FIG. 26 illustrates the operation of the SSN/Socket function of FIGS. 23 and 25.

FIGS. 27 and 28 illustrate the operation of the DIALOGUE ID function of FIGS. 23 and 25.

FIG. 29 illustrates a database utilized by the DIALOGUE ID function.

FIG. 30 illustrates a database used by the SSN/Socket function.

FIG. 31 illustrates a further database used by the DIALOGUE ID function.

FIG. 32 illustrates a further database used by the DIALOGUE ID function.

FIG. 33 illustrates a further alternative embodiment of the present invention, wherein the traffic handler is combined with the screening function of FIGS. 8–21.

DETAILED DESCRIPTION

Referring first to FIG. 1, a communication system, shown generally at 10, includes an embodiment of the present invention as a portion thereof. The communication system 10 is a multi-network communication system, here shown to include a macrocellular communication network 12, a first microcellular communication network 14, and a second microcellular communication network 16.

The microcellular communication network 12, for purposes of illustration, in the exemplary embodiment, is formed of a Global Systems for Mobile communications (GSM) network. In other embodiments, the macrocellular communication network 12 is alternatively formed of another type of Public Land Mobile Network (PLMN). Analogously, the first and second microcellular communication networks 14 and 16, respectively, are, in the exemplary embodiment, formed of Digital Electronic Cordless Telephone (DECT) systems. The microcellular networks 14 and 16 shall, at times, be referred to as DECT systems. In another embodiment, the networks 14 and 16 are alternatively formed of other types of Private Telephonic Networks (PTNs).

The macrocellular communication network 12 encompasses a macrocellular-region throughout which wireless communications by way of the network 12 are permitted. In conventional manner, the network 12 includes a plurality of spaced-apart base stations, of which two base stations 18 are illustrated in the figure. Each base station 18 encompasses an area defining a cell 20. The cells 20 defined by the base stations 18 collectively form the region encompassed by the network 12.

The base stations are coupled by way of base station controllers 22 to mobile services switching centers (MSCs), such as the mobile services switching centers 24 and 26. The base station controllers 22 are operable, inter alia, to control operation of the base stations 18 coupled thereto. Control operations, such as hand-off decisions and channel allocations, are performed at the controllers 22. Operation of the base station controllers 22, and the mobile services switching centers 24 and 26 of the exemplary embodiment corresponds generally with operation of such devices in existing standards specifications.

The mobile services switching centers 24 and 26 shown in the figure are inter-coupled, here indicated by the lines 28. The MSCs 24 and 26 are further coupled to a Public Switched Telephone Network (PSTN). Such couplings are illustrated by lines 32 and 34, respectively, in the figure.

The GSM network 12 further includes location registers including the home location register (HLR) 36. The HLR 36 is coupled to the MSCs 24 and 26 by way of lines 38 and 42, respectively. The HLR 36 is operable in the GSM-communication network 12, inter alia, to perform wide-area mobility management functions to facilitate call routing to and from mobile subscriber units operable to communicate by way of the communication network 12. Such mobility management functions include, for instance, the maintenance of a subscriber registry. The subscriber registry contains information relating to the subscriber units' whereabouts and status.

The HLR 36 is further coupled, by way of lines 44 and 46, respectively, to mobility servers 48 and 52 of the DECT systems 14 and 16, respectively. In an exemplary embodiment, the mobility servers 48 and 52 are based on MD 110 hardware components. Services supported therefrom are developed on an Erlang platform. Services performed by the mobility servers 48 and 52 include those which are conventionally provided by mobility servers of conventional DECT systems.

The mobility server 48 is coupled to radio exchange equipment 54 by way of lines 56. The radio exchange

equipment **54** includes transceiver circuitry permitting communication with mobile subscriber units, such as the mobile subscriber unit **58**. Similarly, the mobility server **52** is coupled to radio exchange equipment **62** by way of lines **64**. Analogous to the radio exchange equipment **54**, the radio exchange equipment **62** includes transceiver circuitry permitting wireless communications with mobile subscriber units positioned within the area encompassed by the DECT system **16**.

In one embodiment, the mobile subscriber unit **58** forms a dual-mode subscriber unit, selectively operable to communicate with both the GSM network **12** and the microcellular networks **14** and **16**.

The mobility server **48** includes a mobility manager **66** capable of communicating information with the HLR **36**. The mobility manager **66** is further coupled to a storage device **68** which also forms a portion of the mobility server **48**. Similarly, the mobility server **52** includes a mobility manager **72** which is capable of communicating information with the HLR **36**. The mobility manager is further coupled to a storage device **74** which also forms a portion of the mobility server **52**. The mobility server **48** is further coupled to the MSC **24**, here indicated by lines **76**. And, the mobility server **52** is further coupled to the MSC **26**, here indicated by the lines **78**. Both the mobility servers **48** and **52** are further coupled to a PSTN and provide conventional call routing of calls between the PSTN and mobile subscriber units which are regularly registered in the respective communication networks **14** and **16**.

The storage devices **68** and **74** store location information related to subscriber units operable in the respective networks associated with the mobility servers **48** and **52**, respectively. As shall be described below, such location information can be updated during operation of an embodiment of the present invention. In one embodiment, the storage devices **68** and **74** further store service subscription information related to service subscriptions to which the subscriber units are subscribed.

During operation of an embodiment of the present invention, the wide-area mobility management functions provided by the GSM network **12** are further utilized by the DECT systems forming the microcellular networks **14** and **16**. Such utilization provides wide-area mobility to mobile subscriber units operable in the networks **14** and **16**. Thereby, communications with mobile subscriber units of the networks **14** and **16** are permitted when such subscriber units roam beyond the areas encompassed by the networks in which the subscriber units are regularly registered, viz., the subscriber units' "home" network. For instance, when the mobile subscriber unit **58** roams beyond the microcellular network **14** and into, for instance, the microcellular network **16**, the wide-area mobility management functions provided by the GSM network **12** are utilized to facilitate communications with the "roaming" mobile subscriber unit. In an embodiment having dual-mode subscriber units, the wide-area mobility management functions provided by the GSM network are utilized by the subscriber units when communicating by way of the networks **14** and **16** and also when communicating by way of the GSM network **16**.

Mobile application part (MAP) interfaces are introduced into the mobility servers **48** and **52**, respectively. The MAP is specified in European Telecommunication Standard (ETS) 300 599, GSM 09.02 version 4.11.1, November 1995, which is hereby incorporated herein by reference. An analogous standard is the mobility management portion of TIA/EIA/IS-41, promulgated by the Telecommunication Industry Association (TIA) and the Electronics Industry Association (EIA). In one embodiment, five conventional MAP operations are supported by the MAP interface. Namely, update location (which is termed "registration notification" in IS-41), insert subscriber data, delete subscriber data, cancel location, and provide roaming number (termed "routing request" in IS-41) operations are supported by the MAP interface. Such operations are performed, as necessary, to permit communications with the subscriber unit when the subscriber unit roams beyond its home network.

Subscription information associated with mobile subscriber units, such as the subscriber unit **58**, operable in the DECT network **14** are stored not only in the mobility server **48** but also in the HLR **36**. Services pursuant to the subscription in the HLR **36**, however, need not be defined. But, the subscriber unit **58** includes an MSISDN number and an IMSI number allocated thereto. The subscription for the subscriber unit in the HLR **36** is based on such numbers.

The mobility server **48** contains tables permitting transformation between a DECT identity, used to identify the subscriber unit in the DECT system **14** and the MSISDN and IMSI numbers, used to identify the subscriber unit in the GSM network **12**.

The DECT identity, the IMSI, and the MSISDN allocated to the subscriber unit **58** are further defined in each mobility server, such as the mobility server **52**, in each DECT system **16**, or other PTN, in which the subscriber unit **58** is permitted to roam. Such information is predefined in the mobility servers. Such predefined information further includes a predefined service profile which, in one embodiment, is not otherwise transferred from the subscriber units' **58** home mobility server, here server **48**, to a visited mobility server, here server **52**. Each mobility server further includes a series of roaming numbers which are defined in manners similar to the roaming numbers defined in a mobile services switching center or location register of a conventional GSM network. Signaling between the MSCs **24** and **26** and the HLR **36** is routed by using a global title (GT) and subsystem number (SSN). Thereby, the mobility servers **48** and **52** appear to the HLR **36** as mobile services switching centers, similar to the switching centers **24** and **26**. The mobility servers further include unique MSC/VLR addresses, similar to the MSC/VLR addresses which identify the MSCs of the macrocellular network **12**.

FIG. **2** illustrates again the HLR **36** of the GSM network **12** and the mobility servers **48** and **52** of the DECT systems **14** and **16**, respectively. Lines **44** and **46** are again shown to couple the HLR **36** with the mobility servers **48** and **52**, respectively. And, the radio exchange equipment **54** and **62** are again shown to be coupled to the respective mobility servers **48** and **52**. When a mobile subscriber unit, here subscriber unit **58**, roams out of the microcellular network **14**, its home network, and into the microcellular network **16**, the subscriber unit **58** registers with the mobility server **52**. The roaming of the subscriber unit is indicated in the figure by the arrow **84**. The identity of the subscriber unit **58** is indexed against a list of subscriber units permitted to roam. A subscriber unit **58** is assumed to be listed on such list and a transformation between the DECT identity of the subscriber unit **58** and its corresponding IMSI number is performed by the mobility manager **72**.

Second, as indicated by the arrow **86**, the mobility server **52** updates the location information of the subscriber unit with the HLR **36**. Then, and as indicated by the arrow **88**, the HLR **36** provides the mobility server **52** with subscriber data, namely the IMSI and MSISDN numbers, stored in the

HLR 36. And, as indicated by the arrow 92, the HLR 36 causes the mobility server 48 to deregister the old registration of the subscriber unit 58 in the network 14. Thereby, the location of the subscriber unit 58 is updated to indicate its location in the area encompassed by the microcellular network 16, not the microcellular network 14.

FIG. 3 illustrates operation of an embodiment of the present invention by which a call is routed to the subscriber unit 58, regularly registered at the network 14, when the subscriber unit 58 roams into the network 16. Elements of the communication system 10 utilized in the exemplary operation of call routing to the roaming, subscriber unit 58 are shown in FIG. 3 and identified by the same reference numerals used to identify such elements in FIG. 1.

When the mobility server 48 receives a call, such as a call originated at the PSTN to be terminated at the mobile subscriber unit, the identity of the subscriber unit is indexed against a list of subscriber units permitted to roam. The subscriber unit 58 is assumed to be on the list and marked as being roaming beyond the network 14. The mobility manager of the mobility server 48 translates the DECT identity of the subscriber unit into an MSISDN number, and the call is routed to the MSC 24, here forming a gateway MSC (GMSC). Such routing is indicated in the FIGURE by the arrow 102. Then, and as indicated by the arrow 104, the MSC 24 interrogates the HLR 36 for routing information to route the call to the roaming, subscriber unit.

Responsive to the interrogation, the HLR 36 requests a roaming number, MSRN, from the mobility server 52, as indicated by the arrow 106. The mobility server 52 returns the roaming number allocated to the subscriber unit 58 to the HLR 36, as indicated by the arrow 108. The HLR 36 thereafter, and as indicated by the arrow 112, returns the roaming number allocated to the subscriber unit 58 to the MSC 24. Once the roaming number is received at the MSC 24, the call is routed to the roaming subscriber unit 58, as indicated by the arrows 114, by utilizing the roaming number. The MSC 24, in one embodiment, generates both a transit call data record and a roaming call forwarding record, for billing purposes, if desired.

FIG. 4 illustrates operation of an embodiment of the present invention by which the wide-area management functions provided by the GSM network 12 of the communication system 10 are utilized to facilitate routing of a call originated at a roaming subscriber unit, here subscriber unit 52 to a mobile subscriber unit operable in the GSM network. Again, elements of the communication system 10 utilized during such operation are identified with the same reference numerals utilized to identify such elements in FIG. 1.

The subscriber unit 58 originates a call, indications of which are received by the radio exchange equipment 62. The call request is provided to the mobility server 52 and the mobility manager 72 thereof indexes the identity of the roaming, subscriber unit against a listing of subscriber units permitted to roam. The subscriber unit is assumed to be on the list and the predefined service profile associated therewith is used for the subscriber unit 58.

The call is set up by way of the MSC 26, here forming a gateway MSC (GMSC) and the DECT identity of the subscriber unit 58 is used as an A-number. The call is thereafter routed, in conventional fashion pursuant to the GSM network, to be terminated at the mobile subscriber, here a mobile subscriber 122. That is to say, the MSC 26 interrogates the HLR, as indicated by the arrow 124, for routing information. Such routing information is received at the HLR 36 from the MSC 24, as indicated by the arrow 126, and a visited location register (not shown) associated therewith. The routing information is provided to the MSC 26, as indicated by the arrow 128. Responsive to the routing information, the call is routed from the MSC 26, to the MSC 24, as indicated by the arrow 130, and thereafter to the appropriate base station 18, as indicated by the arrow 132. The call is thereafter terminated at the mobile station 122, as indicated by the arrow 134.

FIG. 5 illustrates operation of an embodiment of the present invention which permits routing of a call originated by a roaming, subscriber unit, here subscriber unit 58, to another subscriber unit, here subscriber unit 136, positioned in another DECT network, here DECT network 14. The roaming, subscriber unit 58 generates a call to the subscriber unit 136. The identity of the subscriber unit 58 is indexed against a list of permitted roaming subscriber units. The subscriber unit 58 is assumed to be listed on the list, and a predefined profile is allocated to the subscriber unit. The identity of the subscriber unit 136 is also indexed against a list of permitted roaming, subscriber units. Here, the subscriber unit 136 is assumed not to be listed upon the list of subscriber units permitted to roam. The call is thereby routed as an ordinary call between two DECT networks.

Operation of the present invention permits wide-area mobility management functions provided by a macrocellular communication network to be utilized by a microcellular communication network to facilitate communication with a mobile subscriber. A mobile subscriber regularly registered in one microcellular communication network can roam to another microcellular communication network and utilize the wide-area mobility permitted in a macrocellular communication network to route calls to the roaming, subscriber unit.

FIG. 6 is an example implementation of the mobility management part of the mobility servers 48 and 52 of FIGS. 1–5. The mobility manager 66 (72) can be, for example, a software application executing on the mobility server 48 (52). The server 48 (52) communicates with the HLR 36 via a conventional SS7 signaling channel 65 which passes through the associated MSC (not shown in FIG. 6). The mobility manager accesses the SS7 signaling channel via a conventional communications protocol stack at 61. This protocol stack includes the Transaction Capabilities Application Part (TCAP) layer pursuant to ITU-T (International Telecommunication Union-Telecommunication Standardization Sector) Recommendations Q.771, Q.772, Q.773, Q.774 and Q.775 which are hereby incorporated herein by reference. The protocol stack 61 further includes the Signaling Connection Control Part (SCCP) according to ITU-T Recommendation Q.711, which is hereby incorporated herein by reference. The protocol stack 61 further includes the Message Transfer Part (MTP) according to ITU-T Recommendation Q.701, which is hereby incorporated herein by reference.

A TCAP API 63 interfaces between the mobility manager 66 (72) and the TCAP layer of protocol stack 61. The use of an API, or Application Programming Interface, to interface between a software application and the TCAP layer is well known in the art. The TCAP API is conventionally used for embedding MAP operations in TCAP messages and, conversely, for removing embedded MAP operations from TCAP messages.

The TCAP layer itself is a well known conventional provider of an interface between applications and a network layer service, and the SCCP and MTP protocol layers are well known examples of network layer service providers.

The SCCP and MTP protocol layers conventionally provide an interface between the TCAP layer and the conventional SS7 (Signaling System Number 7) signaling channel **65**, as described in ITU-T Recommendation Q.700, which is hereby incorporated herein by reference. The protocol stack **61** translates communication signals input to the TCAP layer using TCAP protocol into corresponding signals for transmission over the SS7 signaling channel **65**. The use of the SS7 signaling channel to support MAP signaling to the HLR is well known in the art.

One problem with the arrangements illustrated in FIGS. **1–6** wherein a microcellular network uses SS7 signaling to access mobility management features of a macrocellular network is that the externally applied signaling from the microcellular network can disadvantageously interfere with existing functions of the macrocellular network that are supported by SS7 signaling within the macrocellular network.

Accordingly, and referencing example FIG. **7**, the present invention provides a firewall **71** between the mobility server **48A** and the associated SS7 signaling channel to HLR **36**, and similarly provides a firewall **71** between the mobility server **52A** and the associated SS7 signaling channel to HLR **36**. The firewall **71** provides a protective isolation between the mobility servers **48A**, **52A** and their respective SS7 signaling channels to HLR **36**, so it is possible to avoid the aforementioned interference with existing functions.

FIG. **8** illustrates a more detailed example of the arrangement of FIG. **7**. The mobility servers of FIGS. **7** and **8** are designated as **48A** and **52A** to reflect the difference between those mobility servers and the mobility servers of FIGS. **1–6**. The difference between the mobility server **48A** (FIG. **8**) and the mobility server **48** (FIG. **6**) is best seen by comparing FIGS. **6** and **8**. In particular, the TCAP API **63** of FIG. **6** interfaces with the SS7 signaling channel **65** via the protocol stack **61**, whereas the TCAP API **63** of FIG. **8** interfaces with a conventional Ethernet system via a conventional TCP/IP application **81**. The mobility server **48A** (**52A**) of FIGS. **7** and **8** may otherwise be identical to the mobility server **48** (**52**) of FIGS. **1–6**.

The TCP/IP application **81** communicates via Ethernet link with another conventional TCP/IP application **83** in the firewall **71**. Applications **81** and **83** could be linked in any desired manner, such as by LAN (Local Area Network) or a private intranet. The TCP/IP application **83** provides a communications interface between the Ethernet system and a communications protocol stack **61A**. The protocol stack **61A** is similar to the above-described conventional protocol stack **61**, in that it includes the conventional TCAP, SCCP and MTP protocol layers. However, the protocol stack **61A** differs from the protocol stack **61** in that it includes a screening function at **85**. The screening function **85** can be implemented as a software module between the TCP/IP application **83** and the conventional TCAP layer as shown in FIG. **8**, or can be incorporated into the software of the TCAP layer. The SCCP and MTP layers interface the screened TCAP layer with the SS7 signaling channel **65** to MSC and HLR.

The screening function **85** operates to screen the various TCAP protocol communications received by firewall **71** from mobility server **48A**. TCAP protocol communications or messages are transmitted from TCAP API **63** to protocol stack **61A** via TCP/IP applications **81** and **83**, as connected by the Ethernet link. Only TCAP communications which pass the screening function **85** are translated by protocol stack **61A** into signals for the SS7 signaling channel **65**. Disallowed communications which are caught in the screening function **85** are not translated and thus are never permitted to access the SS7 signaling channel. The screening function **85** is transparent to communications passing from channel **65** toward the mobility server **48A**.

FIG. **13** illustrates one example of how the screening function **85** may be implemented either as a separate software module or as part of the TCAP protocol layer of protocol stack **61A**. When a conventional TCAP protocol message containing, for example, a MAP operation, is received (**131**), the screening function **85** is implemented at **133**. If desired, the results of the screening function can be logged into an appropriate database or databases in the protocol layer where the screening is done. For example, TCAP communications which pass the screening function can be stored in a "PASS" database, and TCAP communications which fail the screening function can be stored in a "FAIL" database. If the TCAP communication fails to pass the screening function, then control proceeds from **135** back to **131** to await the next TCAP communication. If the TCAP communication passes the screening function, then that communication is permitted to traverse the protocol stack through the TCAP layer, the SCCP layer and the MTP layer to the SS7 signaling channel **65**. The communication is signaled into the macrocellular network on the SS7 signaling channel.

FIG. **9** illustrates an exemplary portion of the screening procedure **133**. In particular, FIG. **9** illustrates an example screening response when a conventional TCAP Invoke request pursuant to ITU-T Recommendations Q.771–Q.775 is received from TCP/IP application **83**. When the Invoke request is received at **90**, it is first determined at **91** whether or not the operation to be invoked, (for example, a MAP operation) is an allowed operation. If not, then the operation is disallowed at **97** and the TCAP communication is not translated (not allowed to pass through the protocol stack **61A**) to the SS7 signaling channel **65**. If the operation to be invoked is an allowed operation, then the parameters associated with the operation to be invoked are decoded at **93**. The decoding will typically involve conventional decoding techniques according to Abstract Syntax Notation One (ASN.1).

After the parameters have been decoded at **93**, a check parameter procedure is executed at **94**. If the check parameter procedure **94** yields an OK result at **95**, then it is determined at **96** whether more parameters are included in the Invoke request. If so, then the check parameter procedure at **94** is executed again for the next parameter. If there are no more parameters to be checked at **96**, and if all results from procedure **94** are OK, then the operation to be invoked has passed the screening. The screening procedure **133** of FIG. **13** can thus continue to perform any other necessary screening operations, or permit the Invoke request to traverse the TCAP, SCCP and MTP layers to the SS7 signaling channel **65** in conventional fashion. If the check parameter procedure **94** yields any result that is not OK at **95**, then the operation to be invoked is disallowed at **97**.

FIG. **10** illustrates one example of the check parameter procedure **94** of FIG. **9**. It is first determined at **101** whether or not the parameter is to be subjected to the screening process. If not, then an "OK" result is returned at **107**. If the parameter is to be screened at **101**, then it is determined at **103** whether or not the parameter is an allowed parameter. If so, the "OK" result is returned at **107**. If the parameter is not an allowed parameter at **103**, then a "not OK" result is returned at **105**.

FIG. **11** illustrates one example of a screening operation which can be performed when a conventional TCAP Begin

request pursuant to ITU-T Recommendations Q.771–Q.775 (termed "TCAP Query with Permission" in IS-41) is received from the TCP/IP application 83. In particular, if a conventional TCAP Begin request is received at 110, it is first determined at 111 whether or not the destination address is an allowed destination address. If not, then the dialogue conventionally associated with the Begin request is disallowed at 115, and no communication is translated (allowed to traverse the TCAP, SCCP and MTP layers) to the SS7 signaling channel 65. If the destination address is an allowed destination address at 111, it is then determined at 113 whether or not the origination address is an allowed origination address. If the origination address is not an allowed origination address at 113, the dialogue is disallowed at 115. If the origination address is an allowed origination address at 113, then the screening procedure 131 can continue to perform other screening operations, or the Begin request can be permitted to traverse the TCAP, SCCP and MTP layers to the SS7 signaling channel in conventional fashion.

FIG. 12 illustrates one example of a screening operation which can be performed when a conventional TCAP Result request pursuant to ITU-T Recommendations Q.771–Q.775 is received from the TCP/IP application 83. Such a Result request is sent, for example, when the mobility server 48A provides a roaming number in response to a request from HLR. When the Result request is received at 120, any parameters associated therewith (such as a roaming number) are first decoded at 121 in generally the same manner discussed above with respect to the decode parameters procedure at 93 in FIG. 9. After the parameters are decoded at 121, the check parameter procedure 94 of FIGS. 9 and 10 is performed. If the check parameters procedure returns a "not OK" result at 125, then the Result is disallowed at 123, and no communication is permitted to traverse the TCAP, SCCP and MTP layers to the SS7 signaling channel 65.

If the check parameter procedure returns an "OK" result at 125, then it is determined at 127 whether or not any parameters remain to be checked. If so, then the check parameter procedure at 94 is performed again with respect to the next parameter. When there are no more parameters to be checked at 127, the Result associated with the Result request can traverse the TCAP, SCCP and MTP layers to reach the SS7 signaling channel 65. If the check parameter procedure 94 returns a "not OK" result for any parameter, then the Result is disallowed at 123 and no communication is permitted to traverse the TCAP, SCCP and MTP layers to reach the SS7 signaling channel.

The firewall 71 of FIGS. 7–13 can be advantageously implemented in a suitable conventional workstation such as is commercially available from, for example, Sun Microsystems. The necessary hardware and software for implementing the conventional protocol stack 61 are commercially available from, for example, Ericsson Infotech, and the above-described screening procedures can be readily implemented either in the software of the TCAP layer of conventional protocol stack 61, or as a software module between TCP/IP application 83 and the TCAP layer. A conventional connection board for making the connection 87 between the MTP layer and the SS7 signaling channel 65 is also commercially available from ADAX.

Below are described various databases which can be maintained within the screening function of FIG. 8. The information in these databases is used in the screening operations discussed above relative to FIGS. 9–13, as will be clear from the following description.

FIG. 14 illustrates an example of a TCAP operations database including a listing of operations that TCAP is

allowed to invoke, and a listing of operations that TCAP is not allowed to invoke. The database can, as shown in FIG. 14, be accessed and visually displayed by the firewall workstation, thereby permitting the macrocellular network operator freely to move various operations from the allowed operations list to the disallowed operations list. The operations shown in FIG. 14 correspond to conventional MAP operations. These operations may be included either in the allowed or disallowed operations list according to the desire of the macrocellular network operator.

FIG. 15 shows one example of a parameters database including a list of parameters which will be screened and a list of parameters which will not be screened. As above, the operator has full freedom to change any parameter from the screened list to the not screened list.

FIG. 16 shows an example of a database including valid values for a given parameter such as the conventional IMSI (International Mobile Subscriber Identity) number. The database can be displayed as above, and the list of valid IMSI numbers can be specified as a plurality of individual numbers and/or as a range or ranges of numbers. The IMSI number is a parameter associated with the aforementioned "update location" operation.

FIG. 17 is similar to FIG. 16 but shows a parameter database of valid roaming number values.

FIG. 18 illustrates one example of a database that specifies the valid MSC number. As can be seen from the foregoing description, each mobility server in effect acts as an MSC during mobility management operations. Thus, each mobility server has associated therewith an MSC number. Because a given firewall 71 typically communicates with only one mobility server, the database of FIG. 18 will typically have only a single entry, namely the MSC number of the mobility server associated with the firewall. The MSC number is a parameter of the aforementioned "update location" operation.

FIG. 19 is similar to FIG. 18, but illustrates a database for a valid VLR number. Because each mobility server acts as an MSC, it also has a VLR number. Again, a given firewall will typically have associated therewith only one mobility server (see FIG. 7), so the database of FIG. 19 will typically have only one entry. The VLR number is a parameter of the aforementioned "update location" operation.

FIGS. 20 and 21 illustrate respectively the database for valid origination addresses and the database for valid destination addresses. The origination address of FIG. 20 includes an Origination Point Code OPC, an Origination SubSystemNumber SSN, and an Origination Global Title GT, and the destination address of FIG. 21 includes a Destination Point Code DPC, a Destination SubSystem-Number DSSN and a Destination Global Title DGT. For a given firewall 71, the only valid origination address will be the address of the associated mobility manager, and the only valid destination address will be the address of the HLR. Accordingly, the databases in FIGS. 20 and 21 will each typically need only a single entry.

All of the databases of FIGS. 15–21 can be easily accessed and modified in the same general manner as described above relative to FIG. 14.

The above-described databases of FIGS. 14–21, when utilized in conjunction with the above-described screening operations of FIGS. 9–13, permit the firewalls 71 of FIGS. 7–8 to screen communications (e.g. MAP communications) from the mobility managers for the protection of the SS7 signaling channel 65 in the macrocellular network. The firewall workstation can be provided as part of the macro-

cellular network, thereby permitting the operator of the macrocellular network to control incoming signaling on the SS7 signaling channel. Moreover, the firewall can be used to control incoming signaling other than the mobility management (e.g. MAP) signaling described above.

Referring again to FIGS. **2** and **6**, each of the mobility servers at **48** and **52** includes the communications protocol stack **61**. In situations where a very large number of mobility servers **48** and **52** are required to communicate with HLR, the licensing and/or purchasing costs of providing each of the mobility servers with the protocol stack **61** can become quite significant, as well as installation and maintenance of the protocol stacks. For example, some systems may have as many as 200 mobility servers, each of which must communicate with HLR. It is clearly desirable to reduce the typical communications protocol stack licensing costs associated with such a system.

It will also be noted that, in the firewall arrangement of FIGS. **7** and **8**, each firewall **71** includes a communications protocol stack at **61A**. Thus, even though the mobility server **48A** does not include the communications protocol stack **61** shown in FIG. **6**, nevertheless, because each mobility server **48A** has a firewall **71** associated therewith, the arrangement of FIGS. **7** and **8** still requires a communications protocol stack for each mobility server.

Exemplary FIG. **22** illustrates a system wherein a plurality of mobility servers **48A** and **52A** communicate with HLR **36** via a concentrator **221**. The concentrator **221** makes it possible for the plural mobility servers to communicate with HLR using only one communications protocol stack of the type shown at **61** in FIG. **6**.

Exemplary FIG. **23** illustrates the concentrator **221** in greater detail. The concentrator **221** includes the conventional protocol stack **61** of FIG. **6** and a conventional TCP/IP application **239**, and a traffic handler **237** interfacing between the TCP/IP application **239** and the communications protocol stack **61**. The MTP layer of stack **61** is connected to the SS7 signaling channel via the conventional connection **87** of FIG. **8**. The SS7 signaling channel then communicates with another conventional protocol stack **61** in HLR **36**. As shown in FIG. **23**, the concentrator **221** may interface a plurality of mobility servers **48A** to any desired server **235**, for example, a centralized debit platform. In addition, the clients of the concentrator **221** need not be mobility servers as shown in FIGS. **22** and **23**, but could be any plurality of clients that require access to a centralized server such as shown at **235**.

The traffic handler **237** includes an SSN/Socket portion **231** and a Dialogue ID portion **233**. The SSN/Socket section **231** tracks the SubSystemNumbers (SSNs) which the mobility servers **48A** use to identify themselves in their TCAP messages. Such use of SSNs in TCAP messages is well known in the art. Also well known in the art is the use of socket identification (Socket ID) by a TCP/IP server application to identify various TCP/IP client applications. In FIG. **23**, the TCP/IP application **239** functions as a server application, and the TCP/IP applications **81** in the mobility servers **48A** function as client applications. The TCP/IP server application **239** is coupled to the plurality of TCP/IP client applications **81** via a suitable communication network **2301** such as Ethernet, or a local area network (LAN) or a private intranet.

The SSN/Socket section **231** correlates between the Socket IDs used by the TCP/IP server application **239** and the SSNs used by the mobility servers to identify themselves in TCAP messages. Upon initialization of the FIG. **23** system, each mobility server **48A** sends an initializing TCAP message from its client application **81** to the server application **239**. The initializing TCAP message includes the SSN that identifies the particular mobility server. Upon receiving the initializing TCAP message, server application **239** assigns a Socket ID to the mobility server from which the message originated. The SSN/Socket section **231** then stores in a database the relationship between the SSN supplied by the mobility server and the Socket ID assigned by the server application **239**. FIG. **30** shows an example of such a database including the relationship between the SNNs and the Socket IDs. As the initializing TCAP messages are received from the various mobility servers **48A**, the SSN/Socket section **231** fills in the database of FIG. **30**.

In addition to establishing the database of FIG. **30**, the SSN/Socket function **231** provides the server application **239** with the appropriate Socket ID when a TCAP message from the protocol stack **61** is presented to the server application **239** for transmission to a mobility server **48A**. Such a TCAP message would have originated at the server **235**, passed to the concentrator **221** via the SS7 signaling channel, and arrived at the SSN/Socket section **231** in the form of a TCAP message having the conventional SSN to identify the mobility server **48A** to which the message is directed. The SSN/Socket function **231** uses the SSN from the TCAP message to determine from the database of FIG. **30** the appropriate Socket ID. This Socket ID is then passed to the server application **239**, whereupon the server application **239** can forward the TCAP message to the appropriate mobility server **48A**. The above described exemplary operation of the SSN/Socket section **231** is illustrated in example FIG. **26**. At **261**, the SSN/Socket portion **231** stores the one-to-one relationships between the SSNs and the Socket IDs (see FIG. **30**) as the Socket IDs are assigned. Thereafter, when a TCAP message is received (**263**) from the protocol stack of concentrator **221**, the Socket ID is determined from the SSN at **265**. The database of FIG. **30** is used to determine the Socket ID from the SSN. After the Socket ID has been determined at **265**, it is passed to the TCP/IP server application **239** along with the TCAP message (**267**).

Referring now to the DIALOGUE ID section **233** of the traffic handler **237** in FIG. **23**, this section pertains to the Dialogue ID portion of a conventional TCAP message. This portion of a TCAP message identifies the communication, or dialogue, of which the TCAP message forms a part. As an example, a conventional TCAP message from one of the mobility servers would include the SSN to identify the server from which the message originated, and would also include in the Dialogue ID portion a Dialogue ID value to identify the particular communication, or dialogue, of which that message forms a part. Because there are many clients (e.g. mobility servers) connected to the concentrator **221**, and because they carry on their TCAP communications independently of one another, two or more of the clients may select the same Dialogue ID value when composing a TCAP message. The DIALOGUE ID section **233** uniquely identifies each dialogue from each client so that the server **235** can keep track of all of the on-going dialogues with the various clients.

In the description that follows, the term "Client ID" will refer to a Dialogue ID value assigned by a client or the DIALOGUE ID section **233** to a TCAP communication occurring between the client and the DIALOGUE ID section **233**, and the term "Stack ID" will refer to a Dialogue ID value assigned by the DIALOGUE ID section **233** to a TCAP communication occurring between the DIALOGUE ID section **233** and the server **235**.

The DIALOGUE ID section **233** maintains a Dialogue ID database such as shown, for example, in FIG. **29**. If C1=C2 in FIG. **29**, then this means that the client having SSN=10 has assigned the same Dialogue ID value to its communication as has the client having SSN=20. However, the DIALOGUE ID section **233** removes the confusion for the server **235** by assigning unique Stack IDs (S1 and S2) which permit the server **235** to distinguish between the two communications.

FIGS. **27** and **28** illustrate one example of possible operation of the DIALOGUE ID function **233**. In the DIALOGUE ID operation of FIG. **27**, it is first determined at **271** whether a TCAP message has been received. If so, it is then determined at **273** whether the TCAP message is received from the stack **61** of concentrator **221** or from one of the clients **48A**. If the TCAP message is from a client, it is then determined at **275** whether the TCAP message is beginning a new dialogue. If the message does represent the beginning of a new dialogue, then the DIALOGUE ID function **233** assigns a new (i.e. not in the FIG. **29** database) Stack ID at **277**. Thereafter, at **279**, the SSN and Client ID from the received TCAP message are stored in a correlating relationship to the newly assigned Stack ID, as shown in FIG. **29**. As mentioned above, two or more clients can conceivably assign the same Client ID in a TCAP message, so the DIALOGUE ID section **233** must correlate the Client ID and Stack ID to the SSN of the client that originated the message. After storing the Client ID-Stack ID relationship, the Stack ID is at **2701** inserted into the Dialogue ID portion of the TCAP message in place of the Client ID.

If it is determined at step **275** that the TCAP message is not beginning a new dialogue, then at **2700** the Client ID and SSN are obtained from the TCAP message and are used to determine the Stack ID from the FIG. **29** database. Then the Stack ID is at **2701** inserted into the Dialogue ID portion of the TCAP message in place of the Client ID. If it is determined at **2703** that the TCAP message is ending a dialogue, then at **2705** the Client ID-Stack ID relationship is deleted from the database of FIG. **29**, including the corresponding SSN. Thereafter, the DIALOGUE ID section **233** passes the TCAP message to the communications protocol stack **61** at **2707**. This step **2707** follows immediately after step **2703** if it is determined at step **2703** that the TCAP message is not ending a dialogue. After passing the TCAP message to the stack at **2707**, control returns to **271** to await arrival of another TCAP message.

Returning to decision block **273**, if the TCAP message was received from the stack **61** of concentrator **221**, control flows to point A in FIG. **28**. At **281** it is determined whether or not the received TCAP message is beginning a new dialogue. If not, then at **283** the DIALOGUE ID section **233** inspects the Dialogue ID portion of the TCAP message, which will contain the Stack ID, and then uses the Stack ID to determine the Client ID from the FIG. **29** database. The Client ID is then inserted into the Dialogue ID portion of the TCAP message at **285**. It is thereafter determined at **287** whether the TCAP message is ending a dialogue. If so, then the Client ID-Stack ID relationship (including the SSN) is deleted from the FIG. **29** database at **289**, after which the TCAP message is passed to the client at **2807**. If the dialogue is not ending at **287**, then the TCAP message is passed to the client at **2807**. From step **2807**, control returns to point B in FIG. **27** and ultimately to **271** to await another TCAP message.

If the received TCAP message is beginning a new dialogue at **281**, then at **2805** the Dialogue ID value found in the Dialogue ID portion of the TCAP message (which Dialogue ID value was in this case assigned by server **235** of FIG. **23**) is assigned to be the Stack ID, and a new Client ID is assigned. Any Client ID that is not currently listed in the database of FIG. **29** is available as a new Client ID at **2805**. At **2803**, the Client ID-Stack ID relationship is stored (along with the destination SSN) in the database of FIG. **29**. Thereafter, at **2807**, the TCAP message is passed on to the client. Thereafter, control returns to FIG. **27** to await another TCAP message at **271**.

FIG. **24** illustrates a plurality of mobility servers at **48A** and **52A** communicating with a server **241** (such as an HLR or debit platform) via a concentrator **243** which is connected to a bus in common with the mobility, servers and the server **241**.

FIG. **25** illustrates the example concentrator **243** of FIG. **24** in more detail. The concentrator **243** of FIG. **25** is similar to the concentrator **221** of FIG. **23**, except the concentrator **243** and the server **241** communicate with one another via respective TCP/IP applications **251** and **253** and the communication network therebetween, as opposed to the SS7 signaling channel connecting the concentrator **221** and the server **235** of FIG. **23**. In FIG. **25**, the TCP/IP application **253** functions as a conventional server application and the TCP/IP application **251** functions as a conventional client application. As in FIG. **23**, the TCP/IP applications communicate with one another via communication network **2301** such as Ethernet, local area network (LAN) or a private intranet.

Because of the TCP/IP link between concentrator **243** and server **241**, the communications between concentrator **243** and server **241** may be conducted with or without their respective MTP layers. That is, only the TCAP and SCCP5 layers of concentrator **243** and server **241** are needed. Moreover, if the server **241** (e.g. HLR or debit platform) services only the mobility servers and nothing else, for example, in a private system, then only the TCAP layers would be needed.

FIGS. **31** and **32** illustrate databases which are advantageous in the DIALOGUE ID section **233**. The FIG. **31** database maintains a record of the last Client ID assigned by the various clients (clients identified by SSN). FIG. **32** is a database holding the last Stack ID assigned by the DIALOGUE ID section **233**. Maintaining a record of the last Client IDs and the last Stack ID can simplify the process of assigning a new Client ID as at **2805** in FIG. **28** or a new Stack ID as at **277** in FIG. **27**.

FIG. **33** illustrates another alternative to the concentrator embodiments illustrated in FIGS. **23** and **25**. In particular, the embodiment in FIG. **33** combines the screening function **85** of FIGS. **8–21** and the traffic handler **237** of FIG. **23**. Thus, TCAP messages received from the clients **48A** and **52A** of FIGS. **22** and **23** can be screened according to techniques described above. TCAP messages that pass the screening can then be provided to the DIALOGUE ID function. Because the screening function acts only on communications toward the central server, communications toward the clients can pass from DIALOGUE ID section **233** to SSN/Socket section **231**. Because the screening function in FIG. **33** will screen messages from plural clients, (e.g. plural mobility servers), the database of FIG. **20** (valid origination addresses) will in this instance include plural entries, as will the databases of FIGS. **18** (valid MSC numbers) and **19** (valid VLR numbers).

The concentrators illustrated in FIGS. **23**, **25** and **33** can be implemented using a commercially available workstation such as available from Sun Microsystems. The SSN/Socket

section 231 can be realized as a software module in conjunction with the TCP/IP server application 239 which is conventionally available in such a workstation. The DIALOGUE ID function 233 can be implemented as a separate software module operating in conjunction with the software of the TCAP communications protocol layer, or can be implemented as a part of the software of the TCAP layer.

The throughput capacity of the SS7 signaling channel 65 may limit the throughput (in terms of TCAP transactions per second) of the concentrator 221 (FIG. 23) to a throughput level less than the throughput capability of the TCAP layer. The TCP/IP link at 251, 253 and 2301 of FIG. 25 permits the TCAP layer to operate at its full throughput capability.

Although exemplary embodiments of the present invention have been described above in detail, this does not limit the scope of the invention, which can be practiced in a variety of embodiments.

What is claimed is:

1. An interface for connection between a server in a macrocellular communication network and a plurality of client applications in respective microcellular communication networks which are relatively smaller than the macrocellular communication network, comprising:

- a first interface portion for connection to the microcellular communication networks;
- a second interface portion for connection to the server; and
- an apparatus coupled between said first and second interface portions and implementing a communications protocol stack including a plurality of communications protocol layers between said first and said second interface portions, said communications protocol layers including a TCAP layer, said apparatus including a traffic handler that permits all of the client applications to communicate with the server via said communications protocol layers.

2. The interface of claim 1, wherein said first interface portion includes a TCP/IP application.

3. The interface of claim 1, wherein said traffic handler includes a database having assignments between identification numbers used by the respective client applications to identify themselves and socket identifications assigned to the respective client applications by said first interface portion.

4. The interface of claim 1, wherein said second interface portion includes an SS7 signaling channel.

5. The interface of claim 1, wherein said second interface portion includes a TCP/IP application.

6. The interface of claim 1, wherein said communications protocol stack includes a TCAP layer, an SCCP layer and an MTP layer.

7. An interface for connection between a server in a macrocellular communication network and a plurality of client applications in respective microcellular communication networks which are relatively smaller than the macrocellular communication network, comprising:

- a first interface portion for connection to the microcellular communication networks;
- a second interface portion for connection to the server, and
- an apparatus coupled between said first and second interface portions and implementing a communications protocol stack including a plurality of communications protocol layers between said first and said second interface portions, said apparatus including a traffic handler that permits all of the client applications to communicate with the server via said communications protocol layers, said traffic handler includes a database which correlates between identification codes assigned by said traffic handler to respective communications between the server and the client applications and further identification codes assigned to the respective communications by the client applications.

8. The interface of claim 7, wherein said communications protocol layer is a TCAP layer, wherein said communications include TCAP messages, and wherein said further identification codes are parameters of the respective TCAP messages.

9. The interface of claim 7, wherein said traffic handler includes a database for storing therein, for each client application, a respective one of said further identification codes most recently assigned by the client application.

10. The interface of claim 7, wherein said traffic handler includes a database for storing therein a most recently assigned one of said identification codes.

11. A method of controlling communications between a server in a macrocellular communication network and a plurality of client applications in respective microcellular communication networks that are relatively smaller than the macrocellular communication network, comprising:

- receiving messages enroute between the server and the client applications;
- assigning first and second identification codes to each of the messages between the server and the client applications and matching the first identification codes with the second identification codes, including selectively using the first identification codes to determine the respective second identification codes that are matched therewith and selectively using the second identification codes to determine the respective first identification codes that are matched therewith;
- altering a portion of a message passing between one of the client applications and the server, including adding one of a first identification code and a second identification code into the message; and
- sending each of the messages to its destination via a communications protocol stack including a plurality of communications protocol layers, so that all of the client applications are permitted to communicate with the server via said plurality of communications protocol layers.

12. The method of claim 11, wherein said receiving step includes receiving the messages at a communication port, and including matching socket identifications assigned by the communication port to the respective client applications with identification numbers used by the respective client applications to identify themselves, and said step of sending the messages sends the messages based upon the step of matching.

13. The method of claim 12, including using the identification numbers to determine the respective socket identifications that are matched therewith, and using the socket identifications to determine the respective identification numbers that matched therewith.

14. A method of controlling communications between a server in a macrocellular communication network and a plurality of client applications in respective microcellular communication networks that are relatively smaller than the macrocellular communication network, comprising:

- receiving messages enroute between the server and the client applications;
- assigning first and second identification codes to each of the messages between the server and the client appli-

cations and matching the first identification codes with the second identification codes;

altering a portion of a message passing between one of the client applications and the server, including adding one of a first identification code and a second identification code into the message; and

sending each of the messages to its destination via a communications protocol stack including a plurality of communications protocol layers, so that all of the client applications are permitted to communicate with the server via said plurality of communications protocol layers;

wherein said sending step includes using an SS7 signaling channel to send the messages.

15. The method of claim **11**, wherein said sending step includes using a TCP/IP application to send the messages.

16. The method of claim **11**, wherein the step of altering a portion of a message alters the portion of the message passing from one of the client applications to the by adding one of said first identification codes into the message.

17. The method of claim **16**, wherein said portion is a dialogue identification portion of a TCAP message.

18. The method of claim **16**, wherein the step of altering a portion of a alters a portion of a message passing from the server to one of the client applications by adding one of said second identification codes into the message passing from the server to the one of the client applications.

19. A method of controlling communications between a server in a macrocellular communication network and a plurality of client applications in respective microcellular communication networks that are relatively smaller than the macrocellular communication network, comprising:

receiving messages enroute between the server and the client applications,

assigning first and second identification codes to each of the messages between the server and the client applications and matching the first identification codes with the second identification codes;

altering a portion of a message passing between one of the client applications and the server, including adding one of a first identification code and a second identification code into the message; and

sending each of the messages to its destination via a communications protocol stack including a plurality of communications protocol layers, so that all of the client applications are permitted to communicate with the server via said plurality of communications protocol layers;

wherein the step of altering a portion of message alters the portion of a first message passing from one of the client applications to the server by adding one of said first identification codes into the first message, and alters a portion of a second message passing from the server to one of the client applications by adding one of said second identification codes into the second message passing from the server to the one of the client applications;

wherein said portions are dialogue identification portions of respective TCAP messages.

20. The method of claim **11**, wherein the step of altering a portion of a message alters the portion of the message passing from the server to one of the client by adding one of said second identification codes into the message.

21. A communication system, comprising:

a plurality of microcellular communication networks including respective client applications;

a macrocellular communication network that is relatively larger than said microcellular networks, said macrocellular network including a server; and

an interface coupled between said server and said plurality of microcellular networks, said interface including a first communication interface coupled to said microcellular communication networks, a second communication interface coupled to said server, and an apparatus coupled between said first and second communication interfaces and implementing a communications protocol stack including a plurality of communications protocol layers between said first and second communication interfaces, said apparatus including a traffic handler that permits all of the client applications to communicate with the server via said communications protocol layers, said traffic handler matches identification codes assigned by said traffic handler to respective communications between the server and the client applications and further identification codes assigned to the respective communications by the client applications.

22. The system of claim **21**, including an SS7 signaling channel connected between said interface and said server, said microcellular networks each including a TCP/IP application, said interface including a further TCP/IP application, said TCP/IP applications of said microcellular networks coupled to said further TCP/IP application.

23. The system of claim **22**, wherein said further TCP/IP application is a server application and said TCP/IP applications of said microcellular networks are client applications.

24. The system of claim **21**, wherein each of said microcellular networks includes a TCP/IP application, said interface includes first and second TCP/IP applications, and said server includes a TCP/IP application, said TCP/IP applications of said microcellular networks coupled to said first TCP/IP application of said interface, and said TCP/IP application of said server coupled to said second TCP/IP application of said interface.

25. The system of claim **24**, wherein said first TCP/IP application is a server application and said second TCP/IP application is a client application.

26. An interface for connection between a server in a macrocellular communication network and a plurality of client applications in respective microcellular communication networks which are relatively smaller than the macrocellular communication network, comprising:

a first interface portion for connection to the microcellular communication networks;

a second interface portion for connection to the server; and

an apparatus coupled between said first and second interface portions and implementing a communications protocol stack including a plurality of communications protocol layers between said first and said second interface portions, said apparatus including a traffic handler that permits all of the client applications to communicate with the server via said communications protocol layers, said communications protocol stack selectively prohibits some communications from the client applications from passing through said communications protocol stack to the server.

27. An interface for connection between a server in a macrocellular communication network and a plurality of client applications in respective microcellular communication networks which are relatively smaller than the macrocellular communication network, comprising:

a first interface portion for connection to the microcellular communication networks;

a second interface portion for connection to the server; and

an apparatus coupled between said first and second interface portions and implementing at least one communications protocol layer between said first and second interface portions, said apparatus including a traffic handler that permits all of the client applications to communicate with the server via said communications protocol layer, wherein said second interface portion includes an SS7 signaling channel.

28. An interface for connection between a server in a macrocellular communication network and a plurality of client applications in respective microcellular communication networks which are relatively smaller than the macrocellular communication network, comprising:

a first interface portion for connection to the microcellular communication networks;

a second interface portion for connection to the server; and

an apparatus coupled between said first and second interface portions and implementing at least one communications protocol layer between said first and second interface portions, said apparatus including a traffic handler that permits all of the client applications to communicate with the server via said communications protocol layer, wherein said communications protocol layer is a TCAP layer.

29. A method of controlling communications between a server in a macrocellular communication network and a plurality of client applications in respective microcellular communication networks that are relatively smaller than the macrocellular communication network, comprising:

receiving messages enroute between the server and the client applications; and

assigning first and second identification codes to each of the messages between the server and the client applications and matching the first identification codes with the second identification codes, including selectively using the first identification codes to determine the respective second identification codes that are matched therewith and selectively using the second identification codes to determine the respective first identification codes that are matched therewith;

sending each of the messages to its destination via a common communications protocol layer, using an SS7 signaling channel to send the communications.

30. A communication system, comprising:

a plurality of microcellular communication networks including respective client applications;

a macrocellular communication network that is relatively larger than said microcellular networks, said macrocellular network including a server;

an interface coupled between said server and said plurality of microcellular networks, said interface including a first communication port coupled to said microcellular communication networks, a second communication port coupled to said server, and an apparatus coupled between said first and second communication ports and implementing a communications protocol layer between said first and second communication ports, said apparatus including a traffic handler that permits all of the client applications to communicate with the server via said communications protocol layer; and

an SS7 signaling channel connected between said interface and said server, said microcellular networks each including a TCP/IP application, said interface including a further TCP/IP application, said TCP/IP applications of said microcellular networks coupled to said further TCP/IP application.

31. The system of claim 30, wherein said further TCP/IP application is a server application and said TCP/IP applications of said microcellular networks are client applications.

32. The system of claim 21, wherein said communications protocol stack selectively prohibits some communications from the client applications from passing through said communications protocol stack to the server.

33. A method of controlling communications between a server in a macrocellular communication network and a plurality of client applications in respective microcellular communication networks that are relatively smaller than the macrocellular communication network, comprising:

receiving messages enroute between the server and the client applications;

assigning first and second identification codes to each of the messages between the server and the client applications;

sending, using the corresponding first and second identification codes, each of the messages to its destination via a communications protocol stack including a plurality of communications protocol layers, so that all of the client applications are permitted to communicate with the server via said plurality of communications protocol layers; and

selectively prohibiting some communications between the client applications and the server from passing through said communications protocol stack;

wherein the first identification codes comprise socket identifications and the second identification codes comprise subsystem number identifications.

34. A method of controlling communications between a server in a macrocellular communication network and a plurality of client applications in respective microcellular communication networks that are relatively smaller than the macrocellular communication network, comprising:

receiving messages enroute between the server and the client applications;

assigning first and second identification codes to each of the messages between the server and the client applications and matching the first identification codes with the second identification codes;

altering a portion of a message passing between one of the client applications and the server, including adding one of a first identification code and a second identification code into the message; and

sending each of the messages to its destination via a communications protocol stack including a plurality of communications protocol layers, so that all of the client applications are permitted to communicate with the server via said plurality of communications protocol layers;

wherein the first identification codes comprise client identifications and the second identification codes comprise DIALOGUE identifications.

* * * * *